Spring 1984

THE EFFECTS OF WORD LENGTH, WORD FREQUENCY AND WORD REPETITION IN AUDITORY MEMORY (LEXICON, VERBAL ABILITY, PSYCHOLINGUISTICS)

JUDITH LUTZHOFF SCHARFF
University of New Hampshire, Durham

8419558

Scharff, Judith Lutzhoff

THE EFFECTS OF WORD LENGTH, WORD FREQUENCY AND WORD REPETITION IN AUDITORY MEMORY

University of New Hampshire PH.D. 1984

University
Microfilms
International 300 N. Zeeb Road, Ann Arbor, MI 48106

PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark __√__.

1. Glossy photographs or pages ______
2. Colored illustrations, paper or print ______
3. Photographs with dark background ______
4. Illustrations are poor copy ______
5. Pages with black marks, not original copy ______
6. Print shows through as there is text on both sides of page ______
7. Indistinct, broken or small print on several pages __√__
8. Print exceeds margin requirements ______
9. Tightly bound copy with print lost in spine ______
10. Computer printout pages with indistinct print ______
11. Page(s) ____________ lacking when material received, and not available from school or author.
12. Page(s) ____________ seem to be missing in numbering only as text follows.
13. Two pages numbered ____________. Text follows.
14. Curling and wrinkled pages ______
15. Other ____

THE EFFECTS OF WORD LENGTH, WORD FREQUENCY AND WORD REPETITION IN AUDITORY MEMORY

BY

JUDITH LUTZHOFF SCHARFF
B.A. (Psychology), University of New Hampshire, 1978
M.A. (Psychology), University of New Hampshire, 1981

DISSERTATION

Submitted to the University of New Hampshire
in Partial Fulfillment of
the Requirements for the Degree of

Doctor of Philosophy
in
Psychology

May, 1984

This dissertation has been examined and approved.

Dissertation director, John E. Limber
Associate Professor of Psychology

Grant L. Cioffi
Assistant Professor of Education

James R. Davis
Associate Professor of Psychology

Merrill Garrett, M.I.T.
Professor of Psychology

John A. Nevin
Professor of Psychology

ACKNOWLEDGEMENTS

The research for this dissertation was supported in part by a dissertation-year felowship from the Graduate School of the University of New Hampshire.

I would like to acknowledge my gratitude to my advisor, John Limber, whose never ending encouragement and socratic questioning made this project a reality.

I would like to thank the other members of my committee, Merrill Garret, Grant Cioffi, Tony Nevin, and Jim Davis for their careful criticism of this dissertation.

Finally, I would like to acknowledge the debt I owe my family for their continued support and understanding. I am most grateful for the following: to my husband Bob for his insistance upon having an "equal" partner; to Michael for his counsel; to Adam for his humor; and to Sarah for her patience.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

THE EFFECTS OF WORD LENGTH,WORD FREQUENCY AND WORD REPETITION IN AUDITORY MEMORY

by
JUDITH LUTZHOFF SCHARFF

University of New Hampshire
May, 1984

Four auditory lexical decision experiments were run to assess the effects of word frequency, word length, and word repetition. Experiment I examined the effects of word length, wortd frequency, and stimulus repetition on RT. The results demonstrated a significant main effect for length and frequency and a significant length by frequency interaction. Long words showed the greatest frequency effect. There was no significant repetition effect. In this experiment the repeated stimuli were separated by at least seven minutes. Experiment II examined the effect of stimulus repetition with the repeated stimuli separated by 0-15 stimuli. This experiment demonstrated a significant repetition effect, but no frequency effect. Experiment III treated word length as a continuous variable and word frequency as a dichotomized variable. Here it was demonstrated that word length accounted for 10% of the variability. Word frequency accounted for 4.6% of the

variance of polysyllables and 6% of the variance of monosyllables. Further, it was found that there was a frequency effect only for monosyllables under 500 msec long. Experiment IV treated word length and word frequency both as continuous variables. Word length accounted for 9% of the variance in this Experiment. Word frequency accounted for 3.4% of the variance of polysyllables and 4.8% of the monosyllables under 500 msec. Finally, Experiments I,II, and IV included the subject's verbal ability as a predictor of RT. In all three experiments verbal ability was negatively correlated to false positive responses. In Experiment I only, subjects with high verbal ability scores responded faster to stimuli than subjects with low verbal ability scores (mean difference=158 msec).

I. Theoretical Introduction

Any student of psycholinguistics recognizes the tremendous complexities of spoken language. We are inundated daily with human speech which must be rapidly understood (translated/retrieved) and responded to without hesitation. We accomplish this translation from a variety of sources (Southern accents, French accents, rapid speech, slow speech, etc.) in a phenomenologically effortless fashion.

A major step towards understanding this process would be to determine how the brain stores and retrieves the individual words which comprise our vocabulary. Utilizing visual stimuli, experiments designed to discover how this mental 'dictionary' (lexicon) functions have uncovered a very stable phenomenon called the frequency effect. The more often a word is used in one's native language, the more rapidly one can react to/perceive it. This effect is quite robust and has been found in various threshold studies and reaction time studies (Howes & Solomon, 1951;

Solomon & Postman, 1952; McGinnes, Comer & Lacey, 1952; Postman, & Adis-Castro, 1957; Cosky, 1976). Somehow, the lexicon functions such that frequently used words can be accessed quickly.

Theories of lexical memory differ as to how high and low frequency words are stored and accessed. These theories reflect, in effect, the differing views on the degree of inherent structure in human memory. One very popular view is that the memory is ordered so that high frequency words are accessed first(Rubenstein, Garfield & Millikan, 1970; Becker, 1976, Stanners & Forbach, 1973; Forster & Bednall, 1976; Swift, 1977). While these theorists disagree on minor points, they all suggest that properties of the stimulus guide a search of the internal lexicon to a specific location and that words at this location are organized by frequency. Thus a high frequency word, given certain other factors, will be accessed before a low frequency word. This requires a highly structured memory.

One of the widely cited structured models of the lexicon is Forster's (1976). This theory suggests that word memory has a <u>master file</u> and three peripheral access files which organize words by 1) orthographic, 2) phonological and 3) semantic properties. The master file consists of a set of bins containing words which are grouped together. Within each bin, words are organized according to their frequency of occurrence. Accessing an entry for a word in the master file is accomplished by finding the bin number in the appropriate peripheral access file and then searching this bin in the master file. Access to any bin is equivalent; only in the bin does differential word frequency play a role in determining RT.

In contrast, Morton (1970) and Landauer (1975) propose fairly unorganized lexical memories. Morton (1970) proposes a memory system wherein each word has a separate detector called a 'logogen'. The detector for the word cat would be activated to some degree by any letter sequence having an inital c, a middle a and a final t. It might also be activated to a lesser degree by sequences having letters similar to these. It could also be activated, again to a lesser degree, by any sequence having three letters. Any presentation of a word will activate a large number of detectors and the problem arises as to how to make a decision as to which detector is the most strongly activated. Morton proposes that each detector has a set threshold, so that when activation for that stimulus reaches a certain level, the detector fires. High frequency words, in this model, have very low thresholds and hence, are identified more rapidly than low frequency words.

Landauer (1975), in an attempt to show that a relatively unstructured memory can account for experimental data, proposed a model where words are stored each time they are encountered. Thus there is an organization across time, but not across word features, meaning, or frequency. Words are accessed by an undirected limited search. Presumably, frequently used words will have been stored many times across the memory and thus, will have a high probability of speedy access.

Another phenomenon that theories of word storage and retrieval might want to account for is the effect of repetition of stimuli. In lexical experiments dealing with the effects of stimulus repetition, it has been found that reaction times are faster on the second presentation of a word than on the first presentation of the same word. Scarborough, Cortise, and Scarborough (1977) have demonstrated that a repetition effect can greatly reduce the frequency effect. This can be readily explained by either Landauer's or Morton's models. For Landauer's model, if the random search starts where the temporal pattern of storage is being carried on, a recently stored word would have a relatively high probability of being accessed quickly, despite the relatively low absolute frequency. For Morton's model, one could claim that activation of a word temporarily lowers the threshold of the logogen. However, the repetition effect cannot be explained, without complexity, by Forsters and the other more popular ordered memory models.

Finally, theories of lexical storage and retrieval must deal with the interaction of word length and word frequency (McGinnes et al., 1952; Postman et al.,1957; Warm & McCray, 1969; Cosky, 1976; Alford, 1978). In visual stimuli research, word length has typically been operationalized as number of letters. This interaction is generally such that the effect of length is greater for low frequency words than for high frequency words. (See fig.1) It is difficult to reconcile this interaction with models of word memory that account for frequency effects with the order of lexical search (Becker 1976; Forster, 1976; Swift, 1977) or differences in activation thresholds (Morton, 1969), or with Landauer's (1977) random search.

The frequency by length interaction has been utilized as supporting a phonological recoding position (McCusker, Hillenger, & Bias 1981). The hard line of the phonological recoding debate suggests that orthographic information is first translated into phonemic code and then the lexicon is accessed. Indeed, much experimental evidence has accrued which suggests some phonological recoding does take place (Rubenstein, Lewis, & Rubenstein, 1971; Meyer, Schvanenveldt, & Ruddy, 1974; Spoehr & Smith, 1973, 1975; Levy, 1975; Mccusker, Cosky, & Gough, 1977; Martin, 1978; Spoehr, 1978; Stanovitch & Bauer, 1978; Bias, 1979; Hillenger, 1980; McCusker, 1977). In contrast, while not

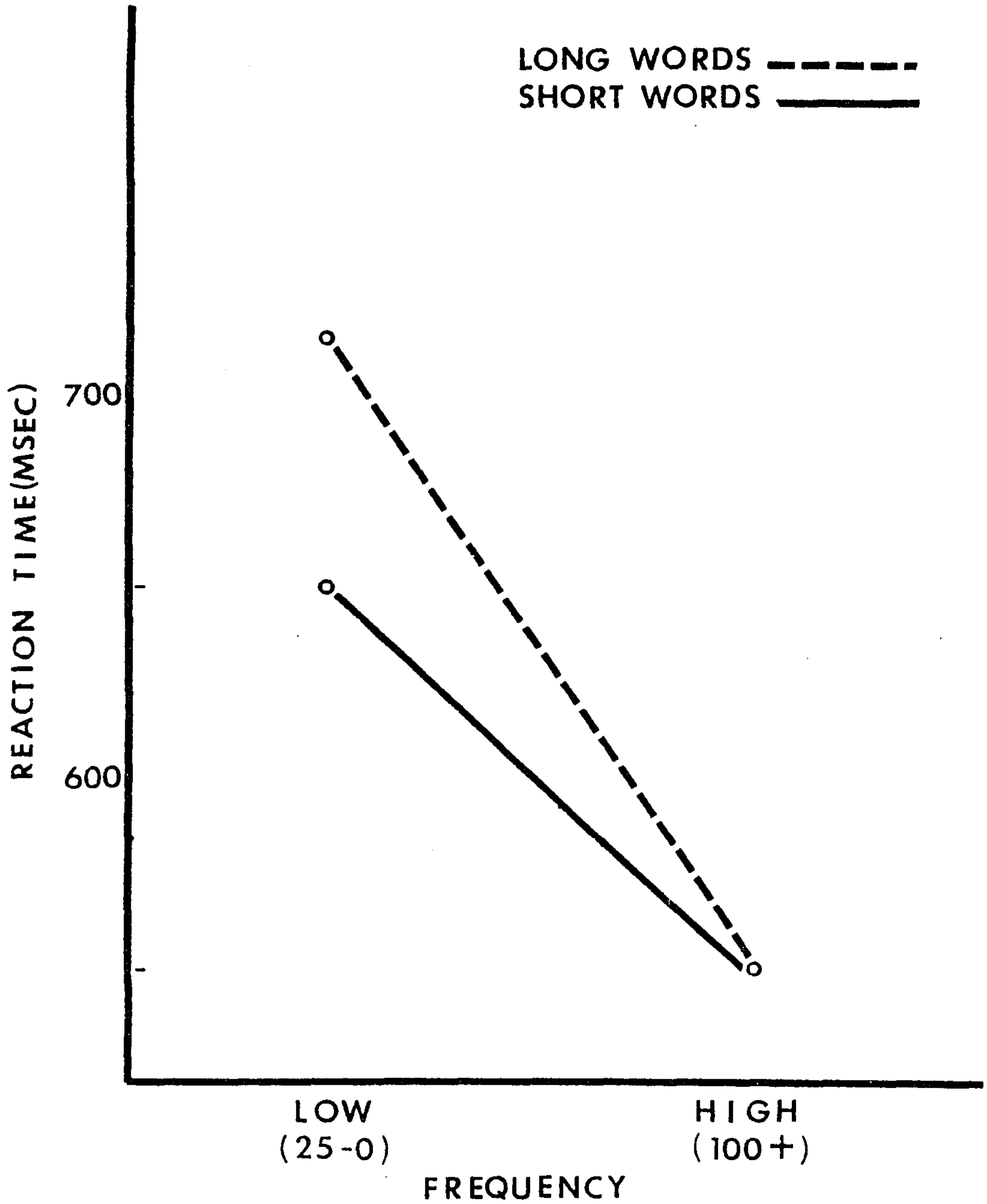

FIGURE 1 VISUAL FREQUENCY BY LENGTH INTERACTION

denying that some phonemic translation may occur, theorists such as Bradshaw(1975),Chomsky (1970), and Frederiksen and Kroll(1976) suggest that phonemic recoding is generally not necessary. Using four, five, and six letter words, Frederiksen et al. (1976), found a length effect for naming latencies, but no length effect for lexical decision latencies. This, they suggested, argued against a phonemic recoding prior to lexical access.

Taking both sides of the debate into question, several researchers have suggested a dual access model of word retrieval (Meyer et al., 1974; Meyer & Ruddy, 1973; Meyer & Gutschera, 1975; McCusker, 1977). The dual access model proposed by McCusker et al.(1981) is similar to Glanzer and Ehrenreich's(1979) two dictionary model in that the subject has one pool of high frequency words and another pool of all the words he or she knows. For the dual process model, given a written stimulus, a phonologically mediated and a visually mediated search would take place in parallel; with the high frequency pool of words represented visually, and the entire pool of words being represented phonologically. The frequency of the stimulus would then determine which representation mediated the termination of the search. The high frequency words would be accessed rapidly by the visual representation,whereas the low frequency words would be accessed via the slower phonological recoding procedure. This model would certainly explain the length by frequency interaction. High frequency words would all be accessed immediately via the visual pool, and one would predict an effect of length of word for the phonological recoding of low frequency words. Finally, if one proposes, as McCusker et al.(1981) do, that a recently encountered stimulus is entered, temporarily into the high frequency pool, then this model would also suffice to explain the repetition effect.

McCusker(1977) suggests that if his dual process model is correct, there would be a smaller frequency effect found for auditorally presented stimuli. This would be because the high frequency words are visually represented and with auditory stimuli the visual templates for high frequency stimuli could not be utilized. In fact, while McCusker, Holly-Wilcox, and Hillenger(1979) did obtain a significant frequency effect utilizing auditory stimuli, this effect was significantly smaller than when the same stimuli were presented visually (see Table 1). Other comparisons across modalities are consistent with this. In two studies comparing the frequency effects for function words (closed class) to all other words (open class), Egido's (1981) auditory stimuli experiment and Bradley's (1978) visual stimuli experiment show the same pattern of results for open class words as McCusker et al. (1979) found. For the open class words, the variance accounted for by frequency in Bradley's visual experiment was 54%,whereas in Egido's auditory study the variance accounted for by frequency was only 18%.

TABLE 1
MEAN RESPONSE LATENCIES IN MSEC FROM THE EXPERIMENT OF MCCUSKER ET.AL.

ITEM	MODALITY AUDITORY	VISUAL
HIGH-FREQUENCY WORDS	742	558
LOW-FREQUENCY WORDS	793	644
WORD FREQUENCY EFFECT	51	86

The Problem

With the discussion of phonological decoding of visual stimuli the problem arises that very little is known about auditory modes of retrieval and recognition. While it is plausible that visual words are mapped into an auditory code, it does not necessarily follow that the access process itself is isomorphic. Most of the present theories of memory and lexical retrival and recognition are based on research using visual stimuli. While contemporary research explicitly limits itself to dealing with printed word recognition, implicitly there is the assumption that what applies to one perceptual modality applies equally to other perceptual modalities. This assumption, however, remains to be tested. Language, both phylogenetically (for the species) and ontogentically (for the individual), develops and is acquired in the auditory mode. Since both the peripheral coding systems and the cortical areas for the visual and auditory systems are separate, it is certainly possible that there are functionally distinct lexicons or lexical processes for audition and vision. It is also possible that once reading is introduced, the visual lexicon is somehow integrated with the already existing auditory lexicon. The latter interpretation would be the most economic, while the former is intuitively appealing considering the physical differences of the incoming stimuli. In the end, this appears to be an empirical question.

II. Experimental Introduction

Using auditory stimuli and a lexical decision task Scharff (1981) studied the effects of word frequency,word duration, and stimulus repetition. The results of this experiment yielded a significant word duration by word frequency interaction. There was no frequency effect for short words while there was a significant frequency effect for long words. (See Table 2.) There was not a significant effect for repetition of real words. For pseudowords there was a significant sex by repetition interaction. (See fig. 2.)

These results suggest that the auditory word memory system must be systematically studied. Experiments I and II examine the effects of word repetition on auditory word retrieval. Experiments III and IV examine the effects of word duration on auditory word retrieval. Further, since it was felt that sex, in and of itself, could not differentially affect reaction times, linguistic ability was added as a predictor to Experiments I, II, and IV. See Experiment I for a full discussion of this issue.

TABLE 2
MEAN RESPONSE LATENCIES IN MSEC FROM
SCHARFF'S AUDITORY EXPERIMENT

LENGTH	FREQUENCY	
	HIGH (100+)	LOW (1-22)
LONG (1200MSEC)	885	1028
SHORT (600MSEC)	878	871

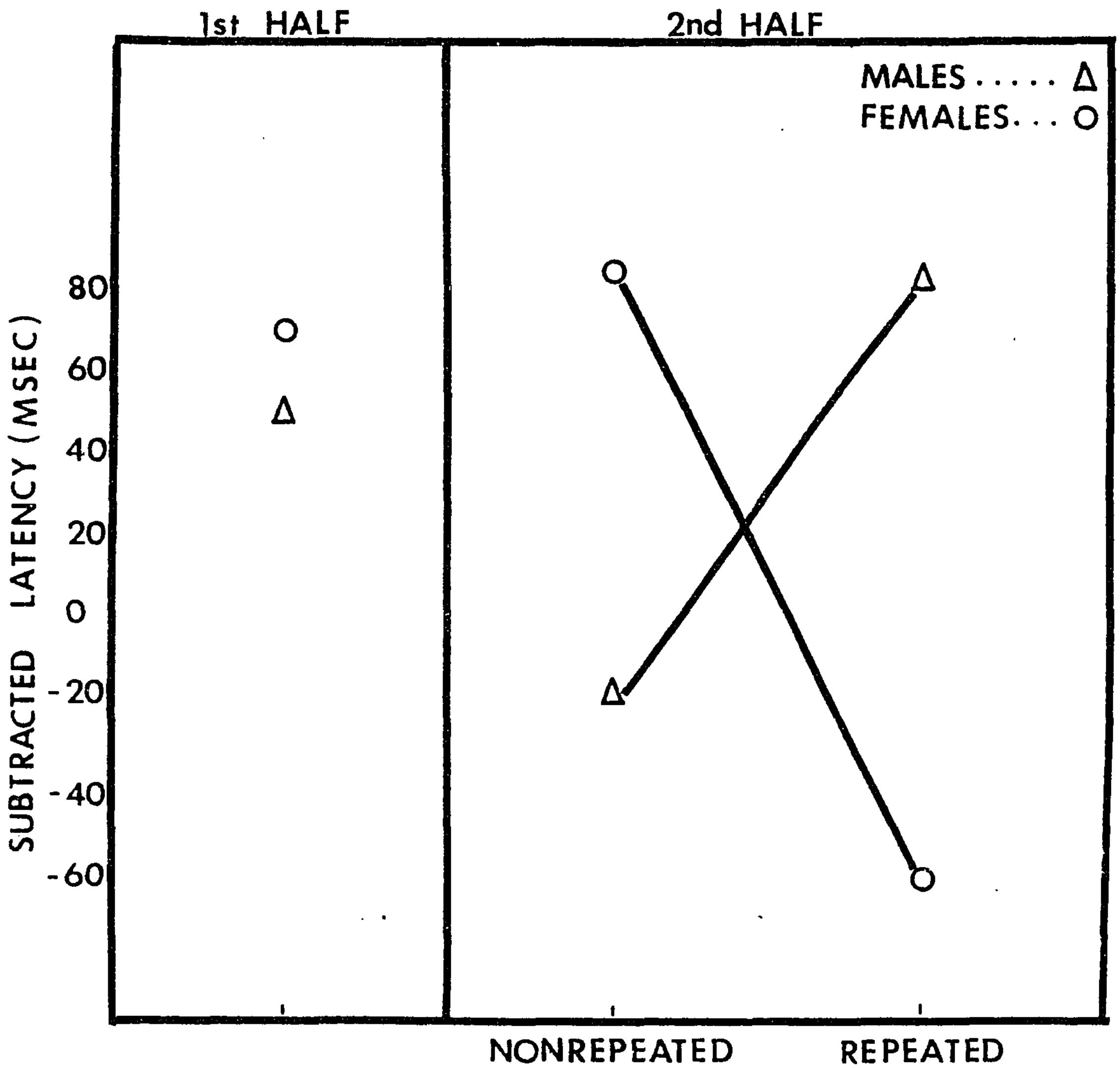

FIGURE 2 PSEUDOWORD SEX BY REPETITION INTERACTION FROM SCHARFF'S 1981 EXPERIMENT

The pseudoword durations (msec) were subtracted from the raw reaction times (msec). All analyses were performed on the subtracted latencies.

A lexical decision paradigm was utilized for all four experiments. In this paradigm subjects are presented with a verbal stimuli and asked to decide whether or not it is a real English word. The subjects' response is timed from the onset of the stimulus presentation. The patterns of response times are then used to make inferences about lexical access. This particular reaction time task was chosen because: 1) it assures that lexical access has taken place; and 2) in visual research, larger frequency effects have been demonstrated with lexical decision tasks than with other RT tasks (e.g. naming tasks, see Swift, 1984).

III. Experiment I

This experiment was performed first to replicate Scharff's 1981 experiment and second to determine is language ability or some other memory strategy could account for the sex by repetition interaction. (See Fig 2.) Since it is unlikely that "sex" per se was the causal variable in the observed individual differences in this study, another causal variable associated with sex was sought.

According to Maccoby and Jacklin (1974), females from about the age of 10 or 11 begin to outscore males in a variety of tests of verbal skills. This advantage for females exists throughout the high school and college years. While sex differences are not found in all studies, when they do exist, the advantage is generally for females (Rosenberg & Sutton-Smith, 1964; Very, 1967; Monday, Hout, & Lutz, 1966-67; Circirelli, 1967; Achenbach, 1969; Walberg, 1969; Shepard, 1970; Svenson, 1971; Bachman, 1972).

Perhaps the sex by repetition interaction Scharff found was due to some underlying linguistic ability of the subject rather than to the sex of the subject. Indeed several researchers findings suggest that subjects with differing vocabularies (low or high) somehow deal differently with linguistic experimental tasks. Dixon and Rothkopf (1979) found a negative correlation between subjects' scores on the Nelson-Denny reading test and false negative responses (i.e., calling a real word a nonword). Butler and Hains (1979) found that subjects with high vocabularies were less affected by word length than subjects with low vocabularies. Further, subjects with high vocabulary scores had faster mean reaction times in a naming task and slower mean reaction times in a lexical decision task than subjects with low vocabulary scores. Hence it was decided to add individual differences of the subjects linguistic abilities as a predictor for this experiment.

To assess the "linguistic skill" of the subjects, the Nelson-Denny Reading test and Vocabulary test were administered to the subjects. These tests were selected 1)because they are designed for relatively skilled readers and, therefore, should be suited for college populations; and 2) because they have national averages of scores through 16 years of schooling.

Since the following experiment utilizes auditory stimuli, one might question the use of a pencil and paper test of linguistic ability. While Scharff's (1981) experiment suggests that the storage and/or retrieval of individual auditory linguistic stimuli might not be isomorphic with the storage and/or retrieval of individual visual linguistic stimuli, it does not follow that there are two <u>isolated</u> linguistic lexicons and retrieval processes. Experimental evidence demonstrates some cross-modality influence of linguistic material. Kirsner & Smith's (1974) study demonstrated a significant cross-modality repetition effect. That is, linguistic stimuli that are presented first to one modality and then repeated via the other modality are responded to faster on the second presentation. This points towards an underlying cross modality linguistic structure and justifies the use of the easily administered pencil and paper test of this unified ability.

Another explanation of the sex by repetition interaction could be differential processing of the pseudoword stimuli by males and females in Scharff's experiment. To test this possibility, at the end of the experimental session, subjects were aurally presented with pseudowords which had been presented once in the experiment randomly mixed with new pseudowords and were asked to make an old-new decision about the stimuli.

Method

Subjects. The subjects were 20 U.N.H. undergraduates (10 males and 10 females) who received credit towards partial fulfillment of their introductory psychology course requirement. All had normal hearing and were native speakers of English.

Stimulus. Tape 1 of Scharff's (1981) experiment was used. words were chosen using the criteria of word frequency and stimulus duration. There were two groups of words based on word frequency: (1) high frequency words (HF) of over a hundred words per million with a range of 103-419 and a mean of 188; and (2) low frequency words (LF) of between 1 and 22 occurrences per million with a mean of 8, as based on the Kucera and Francis (1967) text-based word frequency count. There were two groups of words based on spoken word duration: (1) short words (S) 600 msec to 640 msec in length with a mean of 620 msec; and (2) long words (L) 1160 to 1240 msec in length with a mean of 1200 msec. In taking words from the Kucera and Frances corpus, proper names, abbreviations, homophones, and foreign words were removed from the list. Then words varying in length were chosen in both high and low frequency word classes, (e.g., LHF='division';LLF='dogmatic';SHF='else';SLF= 'elms'). 180 words for each condition were chosen. These 720 words were then recorded on a tape recorder by a male speaker who was unfamiliar with the experiment. The 720 words were then measured for duration of sound on a Grass polygraph. Words were then matched for duration and sorted into frequency groups. 15 stimuli fulfilling the length requirement were picked for each group (LHF,SHF,LLF,SLF). In addition to words chosen from the above list, 70 phonologically legal nonwords were chosen. (See Appendix A) The stimuli were then put in random order with the following limits on the randomization process. No more than three words from the same frequency class were placed in immediate succession. Also, no more than 4 nonwords or 4 real words were allowed to occur in immediate succession.

A tape was then made by re-recording the chosen stimuli from the original tape with all 720 stimuli. This was done to assure that the duration of the word was presented to the subject as measured.

For the first half of the experiment there were 10 LHF, 10 SHF, 10 LLF, 10 SLF, and 40 pseudowords. For the second half of the experiment half of these stimuli were repeated and 60 new items were introduced. Thus in the second half of the experiment half of the experiment half of the items were repeated and half not repeated. Of the real words, half were of long duration and half were of short duration and orthogonally, half were high frequency and half were low frequency. There were then, 5 words in each group (LHF,SHF,LLF,SLF) repeated and nonrepeated.

There were also 20 practice trials at the beginning of the experiment. This yielded 180 stimuli. (See Appendix A.)

Apparatus. The experimental equipment consisted of a two-track tape recorder, headphones, microphone, and peripheral electronic equipment (electronic timers, amplifiers, relays, etc.). The stimuli were on two channels. One was presented binaurally to the listener wearing the headset and the second led to an electric switch triggering the electric timer.

Procedure. Subjects were tested individually. They were asked to respond by saying 'yes' if they thought the stimulus was a word and 'no' if they thought it was not a word. The subject's response was picked up by a microphone attached to the headset. This response stopped the timers. The response and the reaction time was recorded by the experimenter. The first 20 trials were practice trials representative of the test stimuli. During the practice trials, the need for accuracy and speed were emphasized to the subjects. When a subject responded 'yes' to a nonword, the tape recorder was stopped and the subject was asked to repeat the stimulus and give a definition of its meaning. The subject was then advised to respond 'no' to all English sounding words that were not in his/her vocabulary. Subjects whose average response times during the practice sessions were slow (mean over 1000 msec.) were encouraged to respond faster. At the end of the practice session, the remaining 160 trials, with the test stimuli, were presented. The subjects were given a 30 second break after every 40 trials. When the lexical decision tasks were completed, the experimenter read 10 pseudowords that had been presented once in the experiment and 10 new pseudowords. The subject was asked to identify all psuedowords that s/he had heard in the experiment. At a later time, all subjects were given the Nelson-Denny Reading and Vocabulary tests to assess their general linguistic skills.

Results. One subject was dropped from the analyses because her responses failed to stop the timer on 20% of the trials. For the rest of the subjects the reading scores were used to form different language skill groups as follows. Scores from the Nelson-Denny Vocabulary and Reading tests were combined. These scores were then recalculated according to the national averages based on number of years of education. Subjects whose scores were above the 80th percentile were assigned to the high language ability group (7 females and 5 males) and subjects with scores below the 70th percentile were assigned to the low language ability group(2 females and 5 males). The subjects' score for recognition of previously presented psuedowords was determined by subtracting the number of false positives (yes to a stimulus not previously heard) from the total of correct positives. Then a median split was made with 9 high recognizers and ten low recognizers.

The lexical decision data were handled as follows. The mean error rate was 3% with a range from 0% to 8%. Missing data were replaced by the mean reaction time for that word. This occurred in less than 2% of the trials. An initial inspection of each subject's data showed considerable skew in the frequency distribution for RT. This problem was circumvented by using logarithmic transformations of individual reaction times (Winer,1971). For presentations in tables, the averaged data were converted back to milliseconds. The results for real word stimuli were then analyzed in 2X2X2X2X2X2X2 split plot analysis of variance. Sex , Linguistic Score (high or low), Recall ability (high or low), Word Duration (long or short), Word Frequency (high or low), Repetition (i.e. whether or not the word was repeated), and Half(first or second half of the experimental session) were the independent variables. Quasi-F analyses were done so that words could be treated as a random factor and hence the results could be generalized to words as well as to subjects(Winer,1971). Weighted df's were used as suggested by Clark(1977). The main effects of Sex and Recall were non-significant and so another analysis was run collapsing across these two variables. The results showed a main effect for Linguistic Ability $F'(1,19)=10.82$, $p<.01$. Subjects who scored high on the vocabulary and reading tests had mean reaction times 158 msec faster than subjects who scored low on these tests. There was a main effect for Length, $F'(1,31)=25.56, p<.001$. Longer words had longer latencies than short words. There was a significant main effect for Frequency, $F'(1,57)=13.38$, $p<.001$ and a significant interaction of Length and Frequency, $F'(1,36)=6.95$, $p<.05$. An examination of the table of means (Table 3) illustrates that there was an effect for frequency only for long stimuli. There was an effect for Half, $F'(1,30)=7.26$ $p<.05$. The mean response to stimuli in the second half of the experiment was 50 msec faster than to stimuli in the first half of the experiment. There was no significant Repetition effect (i.e. Half by Repetition interaction). Although repeated words did show a 78 msec advantage on the second repetition, this effect (28 msec) was not significantly greater than the overall practice effect. Note that the trend was in the anticipated direction.

The pseudoword data were analyzed in a 2X2X2X2X2X2 split plot repeated measures analysis of variance. Sex,Recall (of previously heard stimuli,high or low), Verbal Ability (high or low), Word Duration(long or short),Half(of experimental session,first or second), Repeated(yes or no) were the independent variables. The main effects for Sex and Recall were nonsignificant and so another analysis was run collapsing across these conditions. The results show a main effect for Verbal

TABLE 3
MEAN RESPONSE LATENCIES IN MSEC FROM
EXPERIMENT I REAL WORD DATA

LENGTH	FREQUENCY HIGH (100+)	LOW (1-22)
LONG (1200MSEC)	853	995
SHORT (600MSEC)	801	798

Ability, $F'(1,20)=14.19$ $p<.005$. Subjects with high scores on the Nelson-Denny reading and vocabulary tests had mean latencies which were 182 msec faster than subjects with low scores on these tests. Word length had an $F'(1,44)=20.57$, $p<.001$ with long words having and average of 185 msec slower latency than short stimuli. No other main effects or interactions were significant.

Discussion The above results suggest that there is a word frequency effect for long auditory stimuli, but not for short auditory stimuli. (In vision, frequency has an effect for stimuli of all lengths. See figs 1 and 3.) Further, replicating Scharff's (1981) study, long real word stimuli were responded to well before the entire stimulus was heard; while short stimuli were responded to almost 200 msec after the stimulus was completed. (See Fig 4.) However, in this experiment there was a frequency effect for both word duration groups; whereas in Scharff's 1981 study there was a frequency effect for long stimuli only.

One of the purpose of this study was to discover if some intervening variable was reponsible for the Sex by Repetition interaction for psuedowords in Scharff's 1981 study. However, the kind of interaction found in the 1981 study did not occur. No group of subjects in the present study showed overall slower latencies to repeated pseudowords. (See fig.5) The effect of Verbal Ability was an additive one. That is, a lower verbal ability score

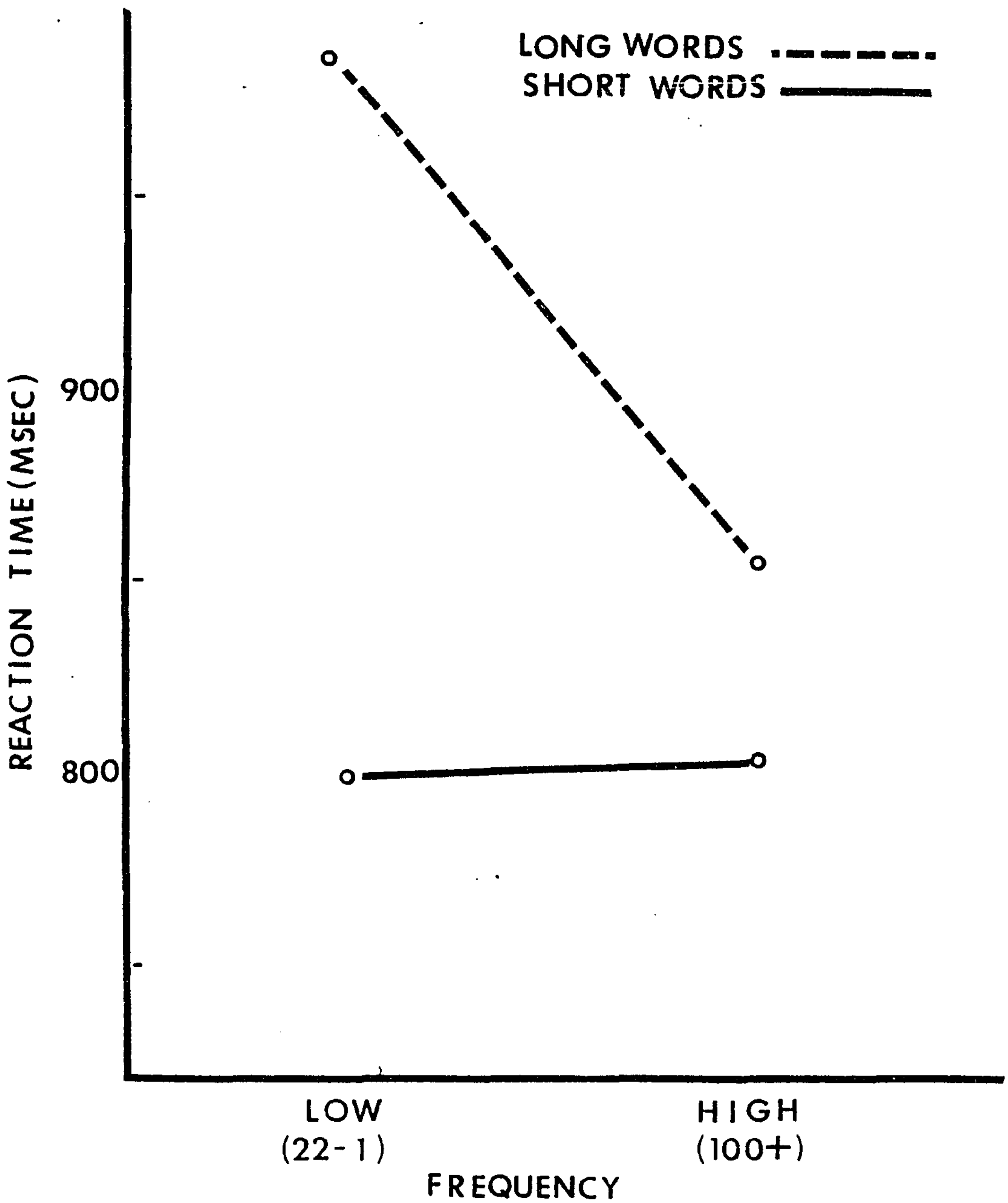

FIGURE 3 AUDITORY FREQUENCY BY LENGTH INTERACTION EXPERIMENT I

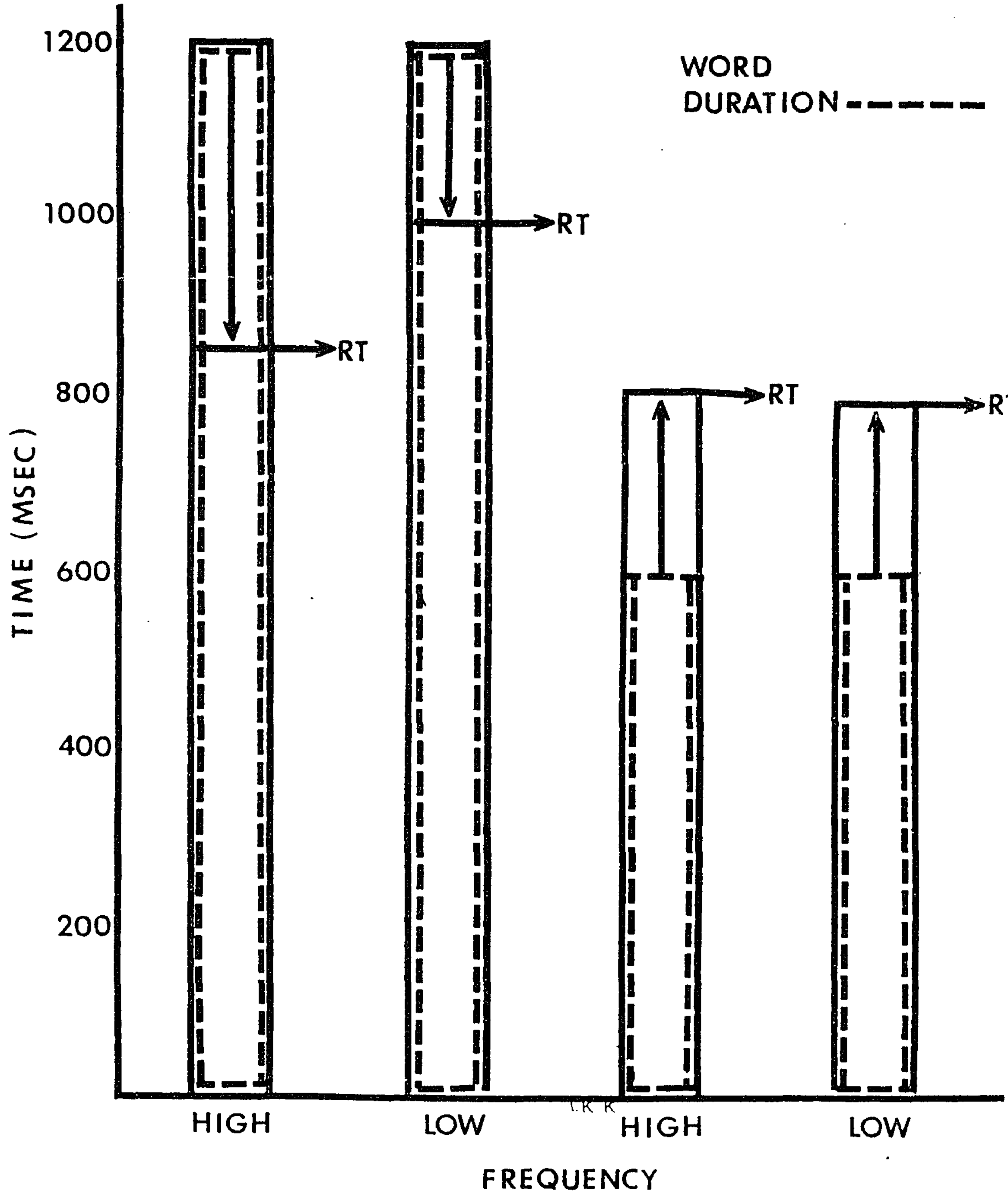

FIGURE 4 THE EFFECT OF WORD DURATION ON REACTION TIME IN EXPERIMENT I

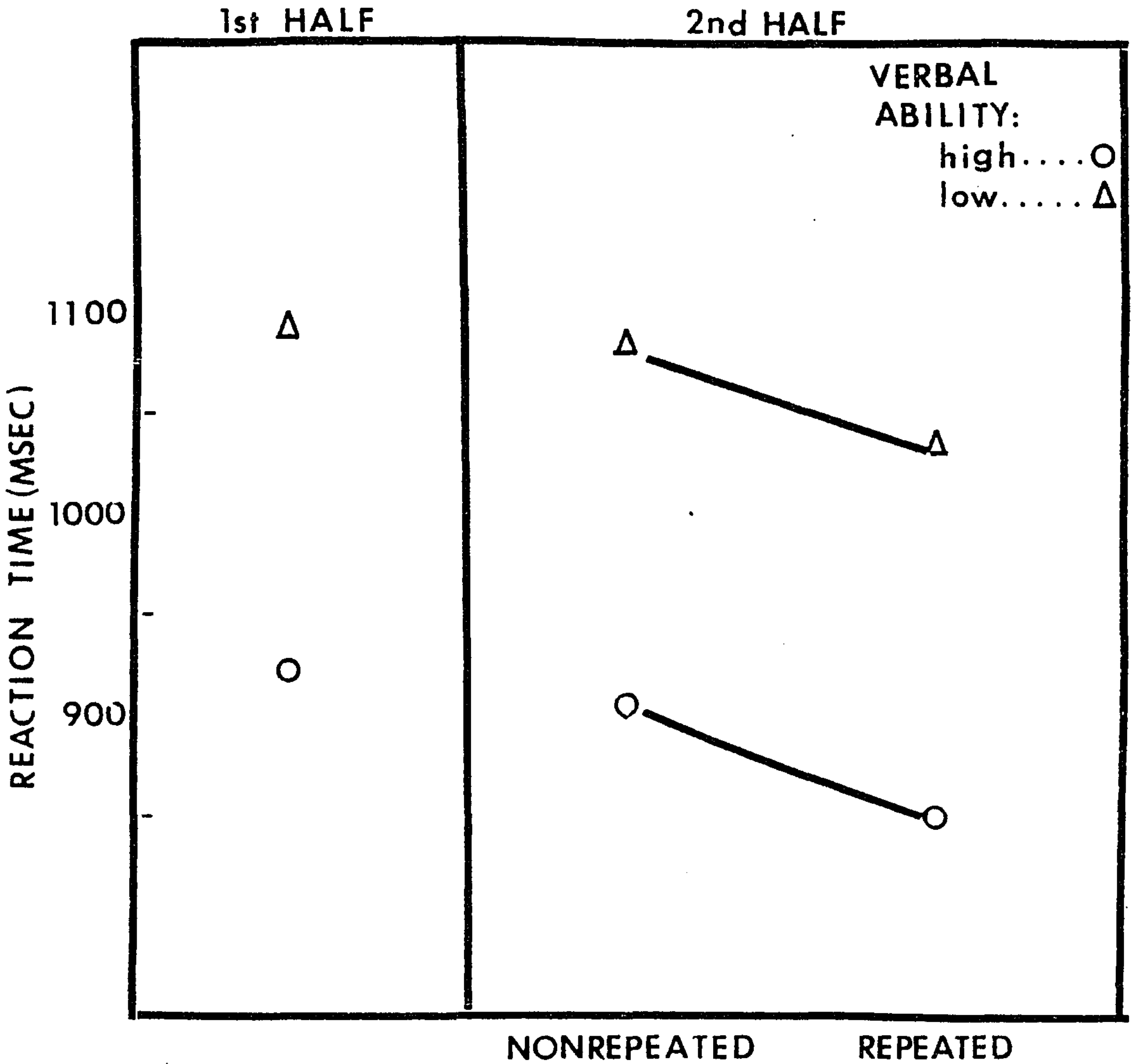

FIGURE 5 THE EFFECTS OF REPETITION AND VERBAL ABILITY FOR PSEUDOWORDS IN EXPERIMENT II

increased over-all reaction times. Further, no interaction of repetition with any variable was found in this study. Both high and low verbal ability subjects showed slightly decreased latencies to the second presentation of stimuli. Hence, verbal ability differences cannot explain the earlier interaction.

Linguistic ability itself had a very large effect and in the opposite direction that would be predicted by Butler et al. That is, in their LDT experiment, subjects with high vocabularies responded more slowly to stimuli than subjects with low vocabulary scores. Subjects with high linguistic ability in this study showed 158 msec advantage for real words. However, as in Butler's et al. study, high linguistic ability subjects were less affected by length than low linguistic ability subjects. Finally, in this experiment, linguistic ability was negatively correlated with false negative responses. This is the same relationship found in Dixon's et al. study. However, false positives were positively correlated with linguistic ability. This confusing state of affairs regarding linguistic ability is discussed further in Chapters IV and VI.

IV. Experiment II

In Experiment I, no repetition effect was found for real word stimuli. However, Scharff's repeated stimuli were heard in a second experimental session which occurred a full 5 minutes after the first experimental session. In Scarborough et.al's (1975) study, stimuli were repeated with separations (lags) of 0,1,3,7,and 15 stimuli. These researchers have reported finding a small repetition effect after a 48 hour separation of experimental sessions and hence it was not felt that a 5 minute rest between experimental sessions would erase the repetition effect. However, the subjects did talk to the experimenter between experimental sessions and, since this was a study of auditory word perception, this procedure may have had some effect on the outcome of the study. Therefore, experiment II was an attempt to more closely replicate Scarborough et.al's original study. Further, since linguistic ability had such a large effect in Experiment I, it was decided to include this variable in the design.

Method

Subjects. 22 UNH undergraduates as described earlier.

Simulus and Design. There were 50 repeated word stimuli, half high frequency (over 100 occurrences per million) and half low frequency (under 11 occurrences per million). There were 40 additional filler real word stimuli. There were 40 repeated phonologically legal pseudowords and 60 filler pseudowords. This gave a total of 190 stimuli. (See Appendix B for test stimuli.)

Procedure. The same experimental equipment as used in Experiment I was used. Subjects were seen individually and were presented with a word/nonword lexical decision task. The first 20 trials were practice trials. Subjects were seen at a later date to assess their verbal ability with the Nelson-Denny Reading and Vocabulary tests.

Results. The mean error rate was 4% with a range from .07% to 5%. Missing data were replaced with the mean reaction time for the word on that presentation. This occurred for less than 1% of the trials. An inspection of the data indicated that a transformation was neccessary, so all scores were converted to log (RT). The results for real word stimuli were analyzed in a 2X2X5X2 split plot, repeated measures analysis of variance. Verbal Ability

(High or low), Presentation (first or second), Lag (0,1,4,7,15), and Frequency (high or low) were the independent variables. The main effect for Verbal Ability was nonsignificant and so another analysis was run collapsing across this variable. The only significant effect was for Presentation, $F'(1,34)= 95.30, p<.000$. The mean reaction time for the second presentation of a word was 126 msec faster than for the first presentation of a word. When only Ss were used in the error term, Frequency was a significant factor, $F(1,21)=86.88, p<.001$. (See Fig 6.)

The pseudowords were Then analyzed in a 2X2X5 repeated measures analysis of variance with Verbal Ability (high or low), Presentation (first or second) and Lag (0,1,4,7,15) as the independent variables. The main effect of Verbal Ability was not significant and so another analysis was run collapsing accross this variable. Using both subjects and words in the error term, Presentation yielded a significant $F'(1,52)=43.15$, $p<.001$. Pseudowords showed a mean decrease in latency of 98 msec on the second presentation. (See right panel of Fig 6.) The main effect of Lag was significant $F'(1,290)=15.25$, $p<.001$. There was also a Presentation by Lag interaction, $F'(1,228)=9.58$, $p<.005$. (See fig 7.) There was a strong repetition effect for psuedowords with a lag of 0 and 1, but this effect drops sharply with longer lags (4-15).

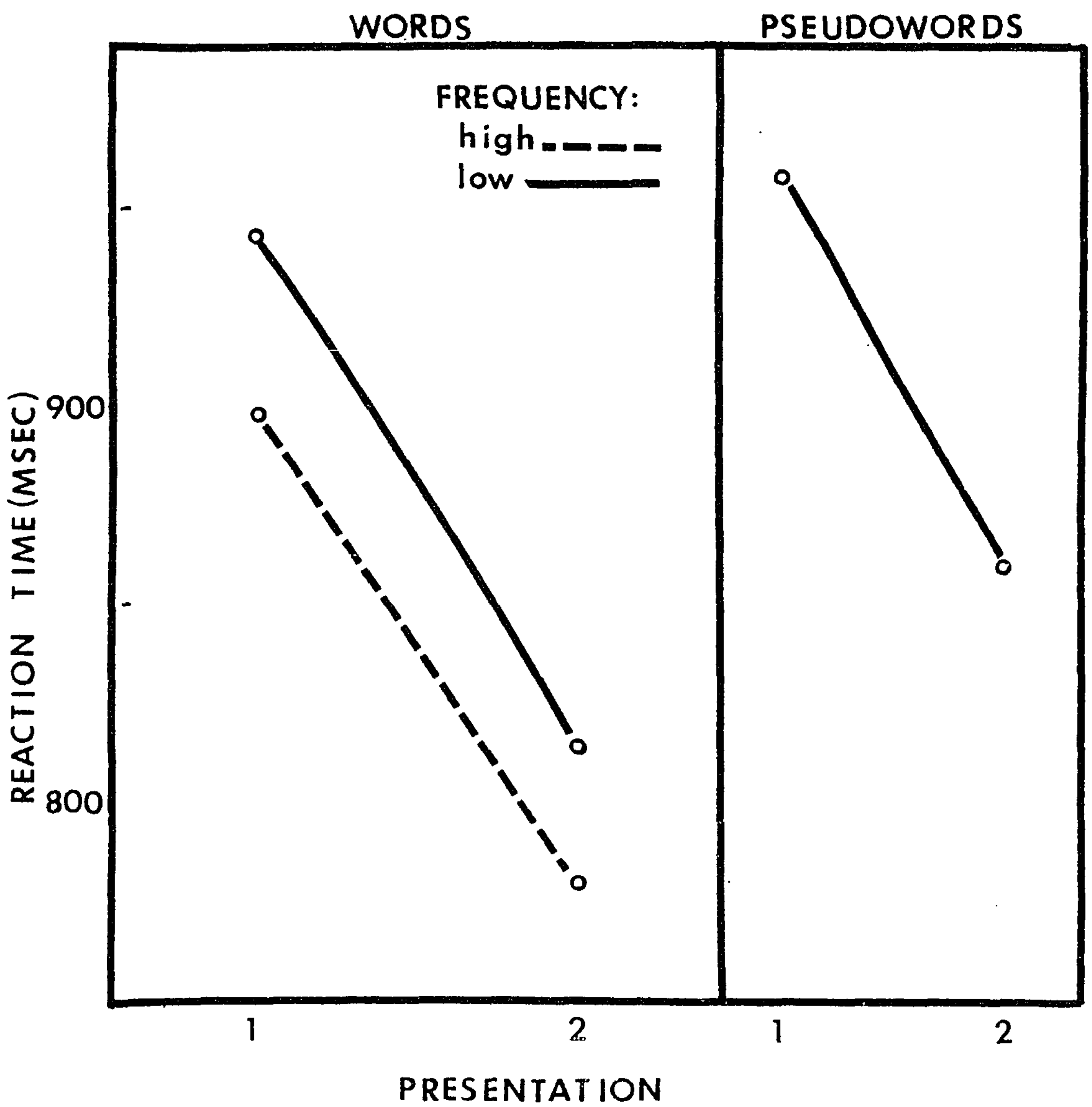

FIGURE 6 REPETITION EFFECT COLLAPSED ACROSS LAGS IN EXPERIMENT II

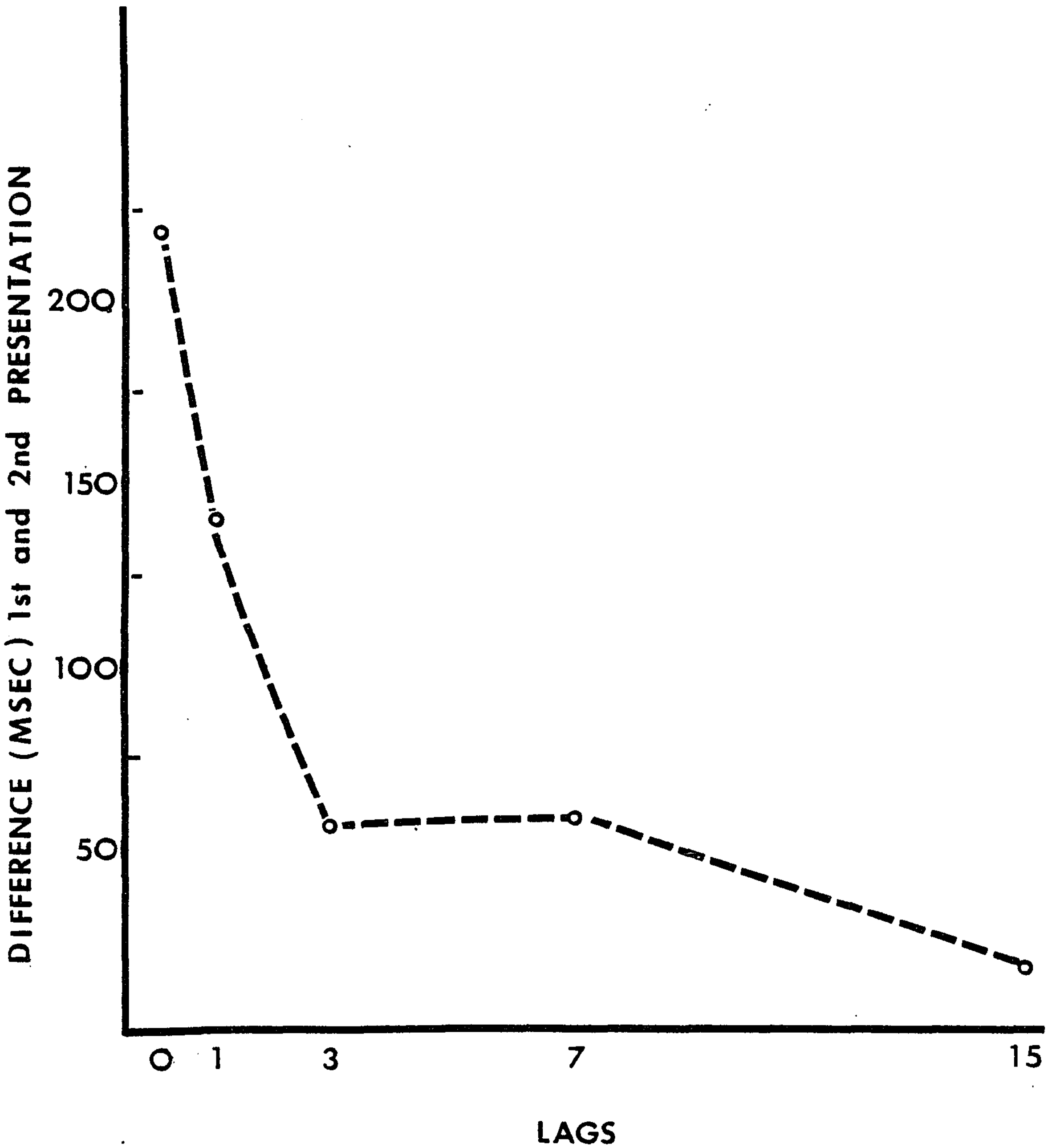

FIGURE 7: EXPERIMENT II. REPETITION AND LAG EFFECTS FOR PSEUDOWORDS

Discussion For both words and pseudowords there was a Repetition effect. For real word stimuli there was no significant Repetition by Lag interaction. (See Fig 8.) For psuedowords there was a significant Lag by Repetition interaction with the mean repetition effect for Lag 0 of 219 msec; Lag 1 of 140 msec; and for Lags 3-7 Of 58 msec.

In this study, using only Ss as a random variable, a highly significant F was obtained for Frequency. However, when Ss and words were treated as random variables, F' was not significant for Frequency. The results from Experiment I suggest that, by not controlling for word duration across frequency conditions, the Frequency effect for words of long duration was masked by the lack of a Frequency effect for words of short duration. (See Table 4 for means of polysyllables and monosyllables.)

Sternberg (1969) has proposed that the mental processes in reaction time tasks can be conceptualized as a series of relatively independent stages of processing. He further suggests that factors which are additive are operating at separate stages. Using Sternberg' additive factors method, Scarborough et al. (1977) argue that the interaction between Frequency and Repetition in their studies suggests that word repetition and frequency effect a common stage in the retrieval process. However the effect of repetition and frequency in the present study appear to be additive and hence can be assumed to be

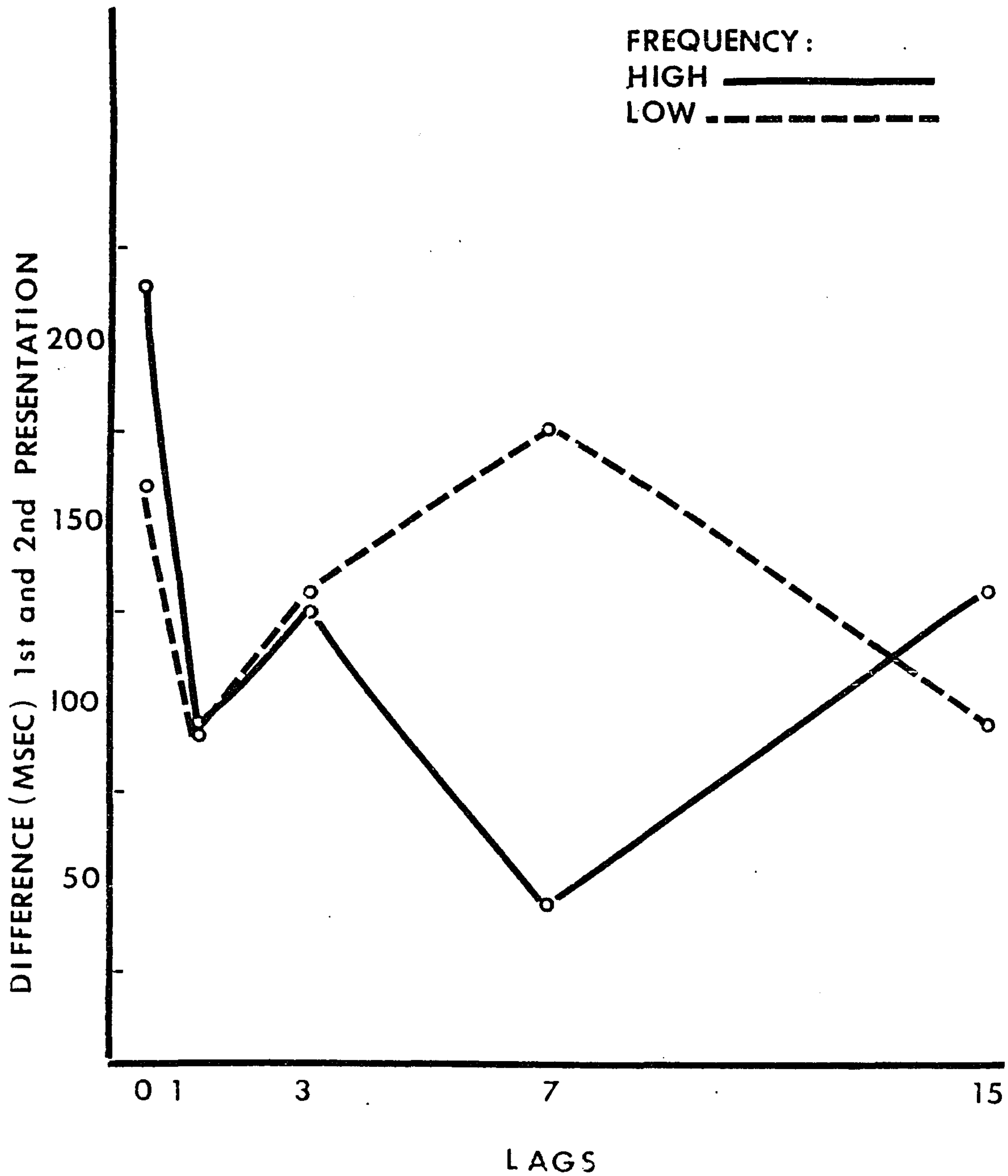

FIGURE 8 EXPERIMENT II REPETITION AND LAG EFFECT FOR REAL WORDS

TABLE 4
MEANS IN MSEC FOR 1ST PRESENTATION
OF MONOSYLLABLES AND POLYSYLLABLES
IN EXPERIMENT II

FREQUENCY	SYLLABLES	
	MONO	POLY
HIGH	898	896
LOW	918	958
FREQ EFFECT	20	62

working on separate stages in the retrieval process.

Surprisingly, since Experiment I manifested such a large effect for linguistic ability, Experiment II demonstrated no such effect. However, linguistic ability in this experiment, as in Experiment I and in Dixon's et al. 1979 study, was negatively correlated to false negative responses. Since Butler et al. found differing effects of linguistic ability across tasks (note, they only had 12 Ss per experiment), it is possible that the blocking of repeated items in the present experiment somehow nullified a differential effect on individual RTs. Individual differences in linguistic abilities do appear to play some role in responses to experimental linguistic materials. Hence, the further study of linguistic ability deserves attention.

General Discussion

Scharff's (1981) experiment and Experiment I of this study suggest that the effects of word frequency, word length, and word repetition are not perfectly isomorphic to the findings of experiments utilizing visual stimuli. First, while a frequency effect was found in the above two studies, word frequency was a determining factor only for stimuli of long duration. (Note, in Experiment I, word length in number of letters of the 'long' stimuli had a mean of nine letters with a range from 6 to 13 letters.

See Appendix A. Frederickson et.al's 1976 study used words which at most, had 6 letters. Perhaps, their stimuli were not long enough to produce the length by frequency interaction.) Second, while a significant word repetition effect was not found in Experiment I, long low frequency stimuli did show the greatest gain in shortened latencies for the second presentation of a word. And finally, it was suggested that the lack of a frequency by repetition interaction in Experiment II might be due to the absence of controls for word duration in this experiment.

The following two experiments will attempt to further clarify the role of word duration and word frequency in auditory word memory.

V. Experiment III

Experiment I demonstrated a frequency effect for long words only. Word length, in that experiment, was dichotomized. The following experiment was undertaken to determine at what stimulus duration word frequency takes effect. Therefore, word length (i.e.duration) was treated as a continuous variable in Experiment III.

Method

Subjects. 37 UNH undergraduates as described earlier.

Stimuli. 55 words varying in number of letters from 3 to 14 were chosen in both high (mean 188) and low (mean 8) word frequency classes as based on the Kucera and Francis word count (1967). In addition, 75 pseudowords were chosen. Duration of the stimuli ranged from 267 msec to 983 msec. (See Appendix C)

Procedure Randomization and experimental procedure were as described earlier.

Results . An inspection of the data indicated that a transformation was neccessary, so all scores were converted to log (rt). The data analyses consisted of several step down multiple regressions. Incorrect responses and missing data, due either to subject error or equipment malfunction, were not included in the analyses. This excluded 5% of the data. Further, four of the high frequency stimuli (instead, actually, ten, neither), chosen for the experiment fell into what Bradley (1978) and Bradley, Garrett, & Zurif (1980) the 'closed class' of words. Closed class words are function words, e.g. "to", "for", etc, and it has been argued by these researchers that function words are not frequency sensitive. Hence the RT's to these words were dropped from the analyses.

The first analysis was a multiple regression of log (RT) as a function of frequency, word duration and the interaction of frequency and word duration (F X WD). Table 5 presents the intercorrelation matrix for the three independent variables. Here it can be seen that log (RT) is related to the frequency of a word (r=-.21), the duration of a word (r=.33), and the interaction of word frequency and duration (r=.32). (See Table 6 for results.)

TABLE 5
CORRELATION MATRIX FOR
EXPERIMENT III

	LOG(RT)	FREQ	WD	FWD
LOG(RT)	1.000			
FREQ	-.206	1.000		
WD	.325	.077	1.000	
FWD	.320	-.755	.685	1.000

TABLE 6
RESULTS FROM EXPERIMENT III

	BETA	F	INCREASE IN RSQ
WD	.885	384.91	.1057
FREQ	-.825	124.73	.0350
FWD	.909	109.73	.0281

To determine where the F X WD interaction occurred, a series of step-down regressions were performed on all data: 1) less than 900 msec long; 2) less than 800 msec long; 3) less than 700 msec long; and less than 600 msec long. For the results of these analyses see Table 7. When word duration is under 900 msec, the Freq by WD interaction is the best predictor of log (RT).

Discussion

An examination of Table 5 demonstrates that word frequency accounts for only 3.5% of the variance and word duration accounts for only 10.5% of the variance. These results indicate that while there is a frequency effect for auditory stimuli in lexical decision tasks, the effect appears to be much weaker than for the same task utilizing visual stimuli. The general finding in visual research is that the frequency of words can account for about 50% of the variability of reaction times (Whaley, 1978).

The step-down analyses on differing word duration groups did not answer the question as to how long a word has to be for word frequency to have an effect. Blosfelds and Bradley (1981), utilizing an auditory simulation technique (i.e. words were presented serially, one letter at a time in a tachistoscope), found an effect of syllables. Monosyllables demonstrated a frequency effect while disyllables showed no such frequency effect.

TABLE 7
LIMITED WORD-LENGTH STEP-DOWN REGRESSIONS
EXPERIMENT III

WORD DURATION LESS THAN	INCREASE IN RSQ FWD	FREQ	WD	TOTAL RSQ
900 MSEC	.096	.024	.003	.123
800 MSEC	.103	.004	.010	.117
700 MSEC	.116	.002	.005	.123
600 MSEC	.091	.018	.004	.113

Blosfeld et al.(1981) interpret these findings as demonstrating the effects of serial processing and suggest that this difference in processing (phoneme by phoneme for auditory can account for any vs. whole word for visual) can account for any cross-modality differential frequency effects. to assess the possible effects of syllables in the present study a post hoc analysis was performed The regression was of Log (RT) as a function of Frequency, Word Duration, Syllable, Syllable x Frequency, Frequency x WD. Table 8 shows the intercorrelation matrix of this analysis. Table 9 shows the beta weights for this analysis. The effect of frequency, when syllables are considered, is reduced (r square=.01) and Freq x SYL becomes a predictor of RT. To unpack the syllable by frequency interaction separate regressions were run on monosyllable and polysyllable data. With only monosyllables in the analysis, the variance accounted for by word frequency was 6%. With only polysyllables in the analysis the variance accounted for by word frequency was 4.6%. The amount of variance accounted for by frequency ignoring syllables (3.5%) was less than the amount of variance accounted for by either monosyllables or polysyllables. To gain a greater understanding of this interaction, step-down regressions were run on monosyllables less than: 900 msec; 800msec; 700 msec; 600 msec; and 500 msec. The variance accounted for with monosyllables under 500 msec was 9%. An analysis run on monosyllables greater than 500 msec

TABLE 8
CORRELATION MATRIX FOR
EXPERIMENT III (SYLLABLES)

	LOG(RT)	FREQ	WD	SYL	SYLFQ	FWD
LOG(RT)	1.000					
FREQ	-.206	1.000				
WD	.325	-.007	1.000			
SYL	.288	.097	.603	1.000		
SYLFQ	-.292	.734	.492	.712	1.000	
FWD	.320	.755	.685	.460	.856	1.000

TABLE 9
RESULTS FROM EXPERIMENT III
SYLLABLES INCLUDED

	BETA	F	INCREASE IN RSQ
WD	1.061	384.91	.1057
SYLFQ	.567	85.56	.0229
FWL	1.30	47.43	.0124
SYL	.297	19.28	.0051
FREQ	.725	121.67	.0308

demonstrated no word frequency effect. The polysyllables were subjected to the same analysis and demonstrated a word frequency effect across all word duration groups. (See Appendix C for stimuli and their respective word durations.)

The monosyllables under 500 msec showed the same frequency effect obtained for Blosfelds et.als (1981) simulated auditory monosyllables. The polysyllables in the present study did not demonstrate the same lack of a frequency effect found by these researchers.

VI. Experiment IV

Experiments I-III all treated word frequency as a dichotomus variable with high and low word frequency groups. The following experiment will treat frequency as a continuous variable.

When reading the literature on the word frequency effect, there appear to be no clear conventions as to what should be utilized as a frequency count. Some experimenters use the single word frequency count from either the Kucera & Frances (1967) or the Thorndike & Lorge (1944) count (Becker, 1972; O'Connor & Forster, 1981). Other researchers utilize some kind of a combined frequency count from the same two corpi (Forster et al., 1976; Bradley, 1978; Glanzer et al., 1979; Jastrezembski, 1981; Gordon, 1983). While still other researchers do not mention whether the frequency count utilized was single word frequency or combined word frequencies (Forster et al., 1973; Spoehrs et al., 1973; Forbach, Stanner, &

Hochhause, 1974; Stanners, Jastrzembski, & Westbrook, 1975; Scarborough, et al., 1977; Goedel & Englert, 1978; Stanovitch et al., 1978; Bias & McCusker, 1980; Forster, 1981; Carrol & Kirsner, 1982; Earhard, 1982; Nas, 1983). When a combined word count is used, there is no standardization as to what counts as a legitimate combination of frequencies: Gordon (1983) "summed over all regular derivational forms"; Bradley (1978) "summed over syntactic inflections (tense and number)"; while Glanzer et al.(1979) "summed across frequencies of the various forms of words (e.g. plurals,possessives)". Finally, when auditory stimuli are used, the question arises as to whether or not a word count based on spoken word frequency should be utilized.

To determine what should 'count' as a frequency word count, four estimates of word frequency were utilized as predictors for the following experiment. The first three predictors were based on the Kucera and Frances (1967) written word counts where frequency is an estimate of written word occurrence based on one million occurrences. The first frequency estimate was the single word estimate in this corpus (e.g. 'AGE', KF count =227; log=2.36). The second frequency estimate was a limited combined estimate, where the word was judged to be either a noun or a verb and tokens were added accordingly (e.g. 'AGE' + 'AGED' + 'AGELESS', KF count=247; log=2.39) The third frequency estimate summed all possible derivation of a word (e.g.

'AGE' + 'AGED' + 'AGELESS' +'AGES'; KF count=298; log=2.47). The fourth frequency estimate was based on single word frequency in the Howes (1966) spoken word count which is based on frequency of occurrence for 250,000 tokens. Because this word count is based on a smaller sample of words, frequency was multiplied by 4 to make its estimate the same as the written word count (e.g.'AGE',Howes count=36 X 4=144; log=2.15).

Carrol and White (1973) have argued that the frequency effect can be better explained as age of acquisition. However, since their count is based on acquisition from 8 years of age to 16 years of age and 80% of the stimuli recorded for this experiment were acquired, according to their count, by age 8 years, a subjective measure of age of acquisition was acquired. That is, subjects were asked to estimate at what age they had each of the test stimuli in their own vocabulary.

Finally, Butler et al. (1979) demonstrated a vocabulary by length interaction (i.e., subjects with low vocabulary scores had slower latencies to long stimuli). Since Experiment I did demonstrate an effect of the subjects' verbal ability, verbal ability was included as a predictor in this experiment.

Method

Subjects. 22 UNH undergraduates as described earlier.

Stimuli. 50 words with four letters and 50 words with 7 or more letters were chosen. These words varied in single word log frequency from .3 to 2.88; in all combinations log frequency from .3 to 2.97, in restricted combined log frequency from .3 to 2.88, and in spoken log frequency from .00 to 3.23. The first three word counts were based on the Kucera and Francis (1967) word count and the last word count was based on Howes (1966) list. 75 phonologically legal psuedowords were also used. (See Appendix D.)

Procedure. There were two experimental sessions. In the first session, the subjects were seen individually and performed the lexical decision task described earlier. In the second session the subjects, seen as a group, were given the Nelson-Denny Vocabulary and Reading tests. They were then presented with a list of the 100 real word stimuli from the first experimental session and asked to estimate at what age each of these words had entered their vocabulary.

Results . An inspection of the data indicated that a transformation was neccessary, so all scores were converted to log RT. The data for three subjects were not analyzed because their error rate was over 10%. The mean rate of error for the remaining subjects was 4.8% with a range from 1% to 8.8%. Incorrect responses and missing data were not included in the analysis. This excluded 9% of the data. Several analyses were run on the data. The first analysis was a multiple step-down regression of log (RT) as a function of Word Duration (WD), Frequency 1 (FQ1),Frequency 2 (FQ2), Frequency 3 (FQ3), and Frequency 4 (FQ4) and was run to determine the best predictor of frequency. (See Table 10 for correlation matrix). Here we see that log(RT) is negatively related to all four frequency counts: single frequency count FQ1 (r=-.126); all possible combinations, FQ2 (r=-.094); limited combinations, FQ3 (r=-.129); spoken frequency count, FQ4 (r=-.134). At the first step of the regression, WD was entered. With WD partialed out the correlations beween log(RT) and the various word frequency counts change. Log (RT) is negatively correlated to all four of the frequency counts: FQ1(r=-.096); FQ2(r=-.07); FQ3 (r=-.088); FQ4 (r=-.085). For F levels of these variables at this stage in the regression, see Table 11.) The second analysis was a multiple step-down regression of log (RT) as a function of WD, AGE of Acquisition (AGE), VERB Ability (VERB), Mono or Poly Syllables (SYL),FQ1 and the interactions of VERBxWD, AgexWD, FQ1xWD, VERBxFQ1, AGExFQ1, SYLxVERB, SYLxFQ1, and SYLxWD. An inspection of the correlation matrix (see Table 12), indicates that log (RT) is significantly positively correlated to WD (r=.30),

TABLE 10
CORRELATION MATRIX FOR
FOUR FREQUENCY COUNTS IN
EXPERIMENT IV

VAR	NUM	LOG(RT)	WD	F1	F2	F3	F4
LOG(RT)	1	1.000					
WD	2	.303	1.000				
F1	3	-.127	-.120	1.000			
F2	4	-.094	-.085	.947	1.000		
F3	5	-.129	-.149	.954	.981	1.000	
F4	6	-.134	-.180	.785	.781	.800	1.000

TABLE 11
PARTIAL CORRELATIONS
(WD PARTIALLED OUT)
EXPERIMENT IV

VARIABLE	PARTIAL CORR	F TO ENTER
F1	-.09572	12.82
F2	-.07161	7.14
F3	-.08877	11.01
F4	-.08484	10.05

TABLE 12
FULL CORRELATION MATRIX
FOR EXPERIMENT IV

VAR	NUM	LOG(RT) 1	WL 2	AGE 3	VERB 4	SYL 5	F1 6	F2 7	F3 8
LOG(RT)	1	1.000							
WL	2	.303	1.000						
AGE	3	.021	.240	1.000					
VERB	4	.026	.013	-.066	1.000				
SYL	5	.090	.607	.186	.009	1.000			
F1	6	-.127	-.120	-.272	-.008	-.066	1.000		
F2	7	-.094	-.085	-.285	-.014	-.050	.947	1.000	
F3	8	-.129	-.149	-.317	-.014	-.111	.954	.981	1.000
F4	9	-.134	-.179	-.303	.025	-.134	.785	.781	.799
VERBWL	10	.254	.783	.146	.602	.475	-.098	-.073	-.123
AGEWL	11	.188	.072	.809	-.038	.455	-.269	-.254	-.314
FWL	12	.049	.043	-.129	.001	.286	.797	.764	.745
VERBF1	13	-.102	-.098	-.270	.442	-.054	.867	.820	.826
AGEF1	14	-.093	.034	.451	-.062	.048	.662	.619	.605
SYLVRB	15	.089	.474	.099	.611	.773	-.056	-.047	-.094
SYLF1	16	-.079	.225	-.153	-.003	.493	.792	.761	.742
SYLWL	17	.025	.918	.247	.013	.857	-.106	-.073	-.146

VAR	NUM	F4 9	VERWL 10	AGEWL 11	FWL 12	VERBF1 13	AGEFQ 14	SYLVRB 15	SYLF1 16
F4	9	1.000							
VERBWL	10	-.147	1.000						
AGEWL	11	-.309	.532	1.000					
FWL	12	.056	.331	.113	1.000				
VERBF1	13	.679	.180	-.252	.695	1.000			
AGEF1	14	.450	-.009	.290	.597	.540	1.000		
SYLVRB	15	-.116	.751	.323	.220	.222	-.002	1.000	
SYLF1	16	.578	.172	-.013	.863	.689	.581	.376	1.000
SYLWL	17	-.179	.719	.682	.402	-.086	.046	.666	.374

VAR	NUM	SYLWL 18
SYLWL	18	1.000

VERBxWD (r=.25), SYLxWD(r=.25), AGExWD (r=.19), and SYL (r=.09). The step-down regression enters the variable left with the highest correlation at each step. WD is the first variable entered. With WD partialed out of the equation, the correlations for the remaining variables change (see Table 13). At this point, clearly FQ1 is the best predictor for the effect of frequency and the interactions of AGEWD and VERBWD become insignificant. At the second step of the regression, SYLFQ1, which has the highest partial correlation (r=-.16) is entered. Table 14 has the results of the analysis. As in Experiment III, WD is significant, accounting for 9% of the variance and SYLxFQ1 is significant accounting for another 2% of the variance. The interactions of FQ1xWD and SYLxWD are significant as are the variables AGE and SYL. These last four variables only add 3% to the accounted for variance. Further, since AGE only had an initial correlation of .02 with log (RT), this may be a spurious finding. Word frequency, by itself, adds nothing to the regression line. Once again, we must look at the SYLxFQ1 interaction to accertain the effect of frequency. Two more analyses were performed: one on the monosyllable data, and one on the polysyllable data with log (RT) as a function of WD, FQ1, and the interaction of FQ1xWD. The analysis of monosyllables demonstrates that none of the variables has a significant effect on RT. (See Table 15 for correlation matrix.) Here log (RT) is related to WD (r=.069) and to FQ1 (r=-.046). Because of the

TABLE 13
PARTIAL CORRELATIONS
SECOND STEP OF REGRESSION
EXPERIMENT IV

VARIABLE	PARTIAL CORR	F TO ENTER
AGE	-.0557	4.32
VERB	.0227	.71
SYL	-.1242	21.74
F1	-.0957	12.82
VERBWD	.0276	1.05
AGEWD	-.0459	2.93
FWD	-.0936	12.26
VERBF1	-.0757	7.99
AGEF1	-.1084	16.49
SYLVERB	-.0655	5.96
SYLF1	-.1589	35.91
SYLWD	-.0796	8.84

TABLE 14
RESULTS EXPERIMENT IV

	BETA	F	INCREASE IN RSQ
WD	-.381	140.27	.0918
SYLF1	-.515	35.91	.0229
SYLWD	1.068	16.38	.0102
AGE	-.125	12.38	.0078
FWD	.265	8.71	.0055
SYL	.419	10.66	.0066
AGEF1	.138	3.886	.0024
AGEWD	-.097	.99	.0006
SYLVERB	.061	.59	.0004
VERBF1	-.031	.37	.0002
VERB	-.025	.03	.0000
VERBWD	.030	.03	.0000
F1	-.010	.00	.0000

TABLE 15
CORRELATION MATRIX
FOR MONOSYLLABLES
EXPERIMENT IV

	LOG(RT)	FREQ	WD	FWD
LOG(RT)	1.000			
FREQ	-.048	1.000		
WD	.069	-.086	1.000	
FWD	.010	.088	.034	1.000

TABLE 16
CORRELATION MATRIX
FOR POLYSYLLABLES
EXPERIMENT IV

	LOG(RT)	FREQ	WD	FWD
LOG(RT)	1.000			
FREQ	-.193	1.000		
WD	.443	-.116	1.000	
FWD	.028	.870	.327	1.000

TABLE 17
RESULTS FROM EXPERIMENT IV
(POLYSYLLABLES)

	BETA	F	INCREASE IN RSQ
WD	.44	198.6	.1918
FREQ	-.19	20.99	.0202
FWL	.02	3.17	.0031

findings regarding monosyllables in Experiment III, another analysis was run on monosyllables under 500 msec. The results indicate that Log (RT) is related to word frequency (r=-.22). In the analysis on polysyllables log(RT) shows significant correlations for WD (r=.435), and FQ1 (r=-.185). (See Tables 16 and 17 for correlations and results.) Polysyllable words only demonstrate a word frequency sensitivity across all word durations; whereas monosyllables demonstrate a word frequency effect only for stimuli under 500 msec. However, again any frequency effects are much smaller in the present auditory studies than that which is generally found in experiments utilizing visual stimuli. (Whaley, 1978)

Discussion

The purpose of this experiment was to determine: 1) if age of acquisition of a word would affect RT; and 2) which word frequency count (single/combined or spoken/written) best predicted the effect of word frequency on RT.

The results demonstrate that age of acquisition, as measured subjectively, does not account for a significant amount of variance of RT in an auditory LDT.

The results also demonstrate that, with word duration partialled out of the regression, logs of the single word count from Kucera and Francis' (1967) written corpus were the best predictor of RT in this auditory LDT. While this certainly simplifies the experimenter's task in choosing stimuli, it should be remembered that this was an auditory experiment and caution should be taken in relating these results to visual experiments. Clearly this analysis could be replicated on already existing visual LDT data to determine which count (single, combined, or restricted combinations) are the best predictor of RT.

In this experiment, as in Experiment III a word frequency effect was found for monosyllables only is their word duration was under 500 msec.

Finally, while the present experiment did not demonstraate an effect of Linguistic Ability on RT, Linguistic Ability, as in Experiments I and II, was negatively correlated with false negative responses. Linguistic Ability appears to affect response criterion (see discussion on Variance in Chapter VII). Further, this effect is not stable across experimental situations (Butler et al., 1979).

VII. Conclusion

The results from the first four auditory experiments on word repetition, word frequency, and word length suggest, when compared to the visual experimental literature, that auditory and visual word memory/retrieval processes may not be identical. The repetition effect, using visual stimuli, persists up to 48 hours. While a repetition effect was demonstrated in Experiment II, the lack of a repetition effect in Experiment I shows that the effect of word repetition in recognition/retrieval of auditory stimuli is short lived (less than seven minutes). In visual experiments, word frequency generally accounts for 50% of the variance of RT's. In Experiments III and IV polysyllables were frequency sensitive at all word durations and monosyllables were frequency sensitive if their word duration was under 500 msec. Apparently the 'short' stimuli in Experiment I (all were monosyllables), demonstrated such a small frequency effect because they were too 'long'. That is, they were all over 500 msec in duration. Finally, in some visual word-memory experiments, the length of a word has an effect only for low frequency words. In the auditory Experiments I,III,and IV, length for all stimuli had a significant predictive value for RT. Before concluding, a discussion of the potential methodological objections to the present studies are necessary. I will address three possible difficulties with the present studies. The first has to do with the experimental equipment as a possible source of error variance . The second has to do with the large standard deviations found in all four experiments. Finally, the third has to do with the frequency counts used.

EQUIPMENT

It could be argued that the experimental equipment, which had several sources of sound adjustment (i.e. lots of knobs), and the tape itself, which could vary slightly with each usage, could lead to more 'noise' in the present auditory experiments than is generally found in similar visual experiments. That is, if the decibel level varied slightly from one subject to the other, or even within one experimental session, this would lead to a great deal of error variance. This underlying source of error might attenuate actual frequency or repetition effects. To test this explanation, a pilot study was perfomed on 35 Ss in Experiment III. After the experimental session, Ss were presented with an additional 4 stimuli in an lexical decision task. The decibel level was set at

10db, 15db, 20db, 25db, and 30db. Seven subjects were tested in each condition. There was no significant decibel level effect on RT. (See Table 18.)

Variance

Reaction time studies generally produce skewed distributions. This causes large Sd's. To deal with this problem researchers usually either Winzorize their data or perform some sort of data transformation. The present experiments utilized Log transformations to handle this problem. The ratio of of mean error to mean RT for the raw data was 1:16 in Experiment I. The ratio of mean error to mean RT for the transformed data in Experiment I was 1:35. Hence, it is clear that the Log transformations gave more power to the analyses.

In the preceding experiments frequency did not demonstrate a significant effect for monosyllables over 500 msec. However, in all four experiments, the standard deviations for each stimulus was quite large (the mean was 160 msec). While the log transformations of the data circumvented this problem, the strongest case possible must be made before rejecting the Null Ho. Hence, the following discussion is aimed at possible ways to reduce the variance in future auditory studies.

TABLE 18
VARIED ATTENUATION STUDY

WORD	10db	15db	20db	25db	30db	MEAN
1	860	977	958	915	1005	943
2	873	767	856	814	654	793
3	726	911	765	806	841	810
4	627	675	646	682	672	660
MEAN=	772	833	806	804	793	802

One place to decrease variance might be the utilization of a manually operated key instead of a voice operated key. Egido's 1981 study, which used a manually operated key, had mean RT's which were approximately 100 msec faster than the RT's in the present studies. Since there is the possibility of a positive correlation between latency and Sd's, faster RT's should yield smaller variances.

Another strategy for decreasing the variance might be the blocking of short and long stimuli. In the present experiments, because the short stimuli were interspersed with the long stimuli, subjects may have adopted a delayed response strategy towards all stimuli. Indeed, an examination of the Sd's for the linguistic ability groups in Experiment I (first half) suggests that these two groups might have been using differing strategies for short stimuli(see Dixon et al. 1979). That is, for the low ability group, the mean Sd for long and short stimuli was practically the same (Long Sd M=193, Short Sd M=188); whereas for the high ability group there was a mean difference of 45 msec (Long Sd M=167, Short Sd M=122). Perhaps the low linguistic ability subjects alone adopted a delayed response strategy. Blocking of short and long stimuli should circumvent this problem.

Frequency Counts

Scharff's 1981 experiment and the present experiments were undertaken to discover if the word memory and/or retrieval processes for vision and audition work similarly. It would be tempting to conclude from these results that auditory word storage/retrieval processes are not similar to these same word processes in the visual modality. However, if there are two lexicons, one visual and one auditory, it is possible that the frequency counts used were not the correct distribution to capture the organization of the auditory lexicon. It is true that Experiment IV utilized Howes spoken word count (1966) and that this estimate of word frequency accounted for roughly the same amount of variance as did Kucera and Francis's written word count (1967). However, Howes word count was obtained by sampling conversations of 5,000 words with college students and hospital patients serving as subjects. This method of estimating spoken language is perhaps limited in scope and hence, the resulting frequency distribution may not reflect the true frequency distribution of words in fluent speech. Since Kucera and Frances sampled 1,000,000 written words from numerous sources (newspapers,textbooks, novels, etc.), perhaps a sample of television shows (PBS, newscasts, talk-shows, movies, etc.) would be a better estimate of the underlying frequency distribution for spoken words.

Consider the frequency distributions of spoken words and written words. It is highly probable that these distributions would not be shaped similarly. Further, it is also possible that the auditory lexicon is highly individualized with regards to frequently used words.

What the preceding results demonstrate is that written word frequency counts are not good predictors of RT in an auditory LDT. On the one hand, this could be because there are two lexicons and the written frequency distribution does not reflect the distribution of words in the auditory lexicon. That is, there could be an auditory lexicon that is organized and accessed in a manner which is identical to the visual system. This interpretation might be empirically demonstrated by gathering frequently spoken words for a group of individuals (e.g., the names of each persons relatives and words which are unique to their profession). The lists of highly personalized high frequency words for several subjects could then be combined into a single list and all subjects could participate in an auditory LDT on this combined list. If a secretary, a psycholinguist, and a behaviorist were the subjects, we might use the names of all of their children, along with the words 'typewriter', 'ditto', 'lexicon', 'memory', 'rat', and 'pigeon' as differential high frequency targets for these three subjects. If each subject had shorter latencies to their own 'high frequency words', then this would lend some empirical support to an individualized auditory frequency distribution and, more importantly to an auditory lexicon organized by frequency.

On the other hand, my experimental findings could be a result of an auditory word storage and/or retrieval system that is dissimilar to the visual word system in its processing of words.

Summary of Results

From the previous experiments the following points can be made:

I. The previous auditory studies show:

   A. A relatively small stable frequency effect for polysyllables.

   B. A relatively small stable frequency effect for monosyllables less that 500 msec in length.

   C. A short lived repetition effect.

   D. A relatively larger length (duration) effect.

   E. Verbal ability may interact in, as yet, unpredictable ways by affecting either via lexical processing or indirectly through task-specific criterion differences.

II. The visual and auditory LDT results are not identical.

   A. Perhaps the wrong frequency counts were utilized in this event:

      1. There could be two lexicons.

      2. We need a more reliable spoken word frequency count.

APPENDIX A
EXPERIMENT I (STIMULI AND MEAN RT'S IN MSEC)

WORD HIGH LONG (FREQ)	HALF 1ST MEAN	HALF 2ND MEAN
PRODUCTION	851	
SEASON	776	
PROBABLY	859	
INFORMATION	914	
EXACTLY	841	
MEAN=	848	
EXPERIENCE	756	674
ORIGINAL	805	739
DIFFERENCE	848	772
ORGANIZATION	984	919
BEAUTIFUL	770	712
MEAN=	832	763
CENTURY		914
ALTHOUGH		865
DEMOCRATIC		844
ENTIRE		992
ESPECIALLY		781
MEAN=		879

WORD LOW LONG (FREQ)	HALF 1ST MEAN	HALF 2ND MEAN
MATRIMONY	903	
RESPOND	1156	
IMPATIENTLY	962	
REVOLUTIONARY	1030	
JOURNALIST	853	
MEAN=	981	
CELERY	1015	896
HOSTILITY	926	846
COMMENTATOR	887	852
BROACH	1236	841
OPPORTUNE	1136	896
MEAN=	1038	866
DETENTION		862
EXPIRATION		1019
COMMONWEALTH		983
DISTURB		915
MAGISTRATE		1051
MEAN=		966

WORD HIGH SHORT (FREQ)	HALF 1ST MEAN	HALF 2ND MEAN
BIG	755	
FEED	872	
RATE	864	
ELSE	947	
ASK	781	
MEAN=	848	
LATE	640	775
RUN	766	771
TEN	875	797
YET	853	713
BIT	748	758
MEAN=	776	763
WHOM		832
LET		800
STOP		743
HIT		639
TYPE		879
MEAN=		779

WORD LOW SHORT (FREQ)	HALF 1ST MEAN	HALF 2ND MEAN
RIPE	783	
CUTE	766	
PIG	782	
HUG	684	
CHIP	821	
MEAN=	767	
BILE	1073	950
COP	794	699
MINK	796	695
WIG	809	762
CAPE	681	666
MEAN=	831	754
MUG		786
RIP		789
ELK		786
BOAT		741
HEN		883
MEAN=		797

(APPENDIX A CONTINUED)

PSEUDOWORD	HALF 1ST MEAN	HALF 2ND MEAN
NAMDER	1368	
DRUPUCTION	993	
HOGULATE	1076	
BASTHUMUS	1181	
DANICKY	983	
SMIRTEE	1034	
TIMEGAST	1066	
GARMEST	950	
WORCHMER	1027	
PUTTMACE	1015	
MEAN=	1069	
NACKWIT	941	1018
COSMIGENOUS	1140	1078
LITTENCE	1135	1078
AFFEL	872	1052
NABICAL	983	858
EQUIMORT	1018	926
EBOTZ	940	934
WORTCHMER	949	850
BRIMACY	1044	952
BLATGRIN	988	888
MEAN=	1001	961
WILLFIDGE		1204
RUBLICK		1031
CABRAPHOR		1151
TRUTTLE		1009
FRABULATION		946
DRAFINITY		1020
FLINGUAGE		769
RIDERMINATE		1030
ENBAST		970
BAVISION		1151
	MEAN=	1028

PSEUDOWORD	HALF 1ST MEAN	HALF 2ND MEAN
ALK	981	
MOLK	984	
QUAP	951	
DIRP	1041	
WUG	975	
PAG	971	
DODE	892	
KALT	735	
UFT	898	
JORT	885	
MEAN=	932	
TIV	927	926
KIPT	838	803
RORT	921	890
LOKE	970	812
CLAT	926	912
GLACK	992	902
FREM	950	857
DUP	788	784
BORK	1047	882
GIRB	910	904
MEAN=	927	867
SMIRPF		1043
YISH		862
DULF		912
PILT		866
PLET		900
PIV		873
BIFEN		871
ZUT		1151
FID		842
TRUKE		955
	MEAN=	928

APPENDIX B

EXPERIMENT II (STIMULI AND MEAN RT IN MSEC)

LAG PRESENTATION	WORD (HIGH FREQ)	1ST MEAN	2ND MEAN	LAG PRESENTATION	WORD (LOW FREQ)	1ST MEAN	2ND MEAN
0				0			
	ANALYSIS	1176	955		FRIGID	841	800
	INFLUENCE	1000	808		COMPASSION	954	823
	FEDERAL	837	803		JOT	877	677
	BOY	808	601		MOSS	980	720
	LOW	1139	716		OBNOXIOUS	887	724
	MEAN=	992	777		MEAN=	908	749
1				1			
	BEAUTIFUL	866	756		ACQUITTED	1080	1061
	LIST	911	810		HEMORRHAGE	754	691
	GROUND	858	810		MUNCH	887	794
	CAR	835	751		COY	894	780
	CENTURY	935	808		OFFSPRING	920	755
	MEAN=	881	787		MEAN=	907	816
3				3			
	HOSPITAL	854	702		INEPT	900	828
	ASSOCIATION	1000	894		ARID	910	738
	BALL	932	742		MUNDANE	1119	985
	DOOR	810	728		CRIB	906	778
	BALANCE	781	684		OMEN	847	701
	MEAN=	875	750		MEAN=	936	806
7				7			
	HOTEL	722	748		INQUEST	1016	867
	COST	887	818		FAD	892	754
	ARMY	798	747		SLY	1287	1086
	CLUB	814	787		MUSTANG	1071	846
	CENTER	838	741		PARACHUTE	932	772
	MEAN=	812	768		MEAN=	1040	865
15				15			
	AVERAGE	1012	815		ENTOURAGE	1206	1044
	BROUGHT	928	798		FORREST	808	751
	AID	989	726		FAN	679	627
	END	867	824		MONOGRAPH	1082	967
	COLLEGE	833	812		PAL	870	779
	MEAN=	927	795		MEAN=	929	834

(APPENDIX B CONTINUED)

LAG	PSEUDOWORD	PRESENTATION 1ST MEAN	2ND MEAN
0			
	POPIDATION	1078	722
	JORT	951	661
	RORT	1007	821
	AFFEL	872	689
	DAPTION	965	814
	GWORFLING	793	645
	MEAN=	944	725
1			
	PLET	871	749
	PAG	997	816
	PUTTMACE	934	836
	WORCHMER	995	898
	FRABULATION	1163	874
	BAVISION	923	871
	MEAN=	981	841
3			
	BORK	879	766
	NAMDER	1047	996
	MOLK	1192	1099
	DRAFINITY	1088	977
	PEVRITH	791	752
	ENBAST	995	1060
	MEAN=	999	942
7			
	PILT	824	772
	BLEEN	1019	943
	EBOTZ	820	771
	PRODRIM	1036	954
	NACKWIT	991	969
	HOGULATE	880	803
	MEAN=	928	869
15			
	TRUTTLE	897	873
	ALK	1026	939
	DUP	740	757
	COSMIGINOUS	1057	1060
	EQUIMORT	987	1010
	BASTUMUS	922	889
	MEAN=	938	921

APPENDIX C
EXPERIMENT III
(WORDS, FREQUENCY, WORD DURATION AND MEAN RT IN MSEC)

WORD	FREQ	WD	MEAN	WORD	FREQ	WD	MEAN
INSTEAD *	173	616	931	PROCTOR	4	675	833
ACTUALLY *	166	540	863	PHOTOGRAPHY	18	833	708
BEYOND	175	525	656	PERSERVERANCE	1	967	914
INDUSTRIAL	143	708	761	BRICK	18	391	637
FAMILY	331	625	692	CHUM	1	550	878
MILLION	204	504	734	CHARITY	8	650	803
DEVELOPMENT	334	742	855	SCULPTURE	11	750	890
FEED	123	550	662	CONTINGENT	3	817	752
TREATMENT	127	567	766	URGE	21	650	801
RISE	102	833	855	SIGNATURE	6	708	855
ORGANIZATION	127	808	961	FOX	13	808	710
HARD	202	542	728	EXCELSIOR	4	983	1054
TEN *	165	392	715	MAP	13	500	702
ADMINISTRATION	161	954	971	DEMARCATION	2	867	1080
LOT	127	533	824	COMPENSATE	3	825	867
KEEP	264	400	636	FIDELITY	8	700	792
SPECIAL	250	542	769	ENTOURAGE	4	954	1113
QUESTION	257	442	678	COOP	3	200	740
DEAL	142	425	678	ADO	4	483	1018
STEP	131	591	805	LETHAL	5	525	851
RESPONSIBILITY	118	983	1011	OAK	15	408	801
STANDARD	110	700	905	DISTURB	10	758	841
SIMILAR	157	567	788	PEN	18	467	705
NEITHER *	141	517	831	DECOMPOSE	1	900	796
FULL	230	517	630	COMPLICITY	7	558	995
ROAD	197	650	764	LOTTERY	1	683	810
JUSTICE	114	700	740	PUB	1	425	760
INCLUDE	113	758	622	COLLECT	16	617	689
MILITARY	212	650	793	FAKE	10	467	680
PLAY	200	417	654	CELLULAR	3	667	974
LIVE	177	500	610	RIM	5	475	703
INDIVIDUAL	239	617	573	FAD	2	575	711
PROBLEM	313	633	709	ORIENTATION	16	879	882
RATE	209	508	781	PRESTO	2	592	1055
LEAD	129	442	674	PUP	2	267	688
HALF	275	533	741	INSTINCT	14	817	823
TOWN	212	542	723	EGOTIST	2	767	835
COMMUNITY	231	642	733	APE	3	403	942
PAID	145	558	800	SEGMENT	10	750	701
HELP	311	408	629	COKE	4	442	926
TYPE	475	475	629	COSTUME	10	583	756
BIG	360	408	708	WED	2	383	1032
HOSPITAL	110	667	690	PRIMACY	5	692	915
FEET	283	500	594	SERMON	12	650	844
PLAN	205	575	739	RIPE	14	542	828
SIZE	138	917	980	APOTHOCARY	3	883	948
FEAR	127	608	653	IMPROBABLE	2	900	710
POPULATION	136	817	787	CLIP	6	425	736
TECHNICAL	120	575	725	BRAG	2	525	776
				RIP	6	367	636

APPDNDIX D
EXPERIMENT IV
(STIMULI, FOUR FREQUENCY COUNTS, WORD DURATION, MEAN RT IN MSEC)

WORD	FREQ1	FREQ2	FREQ3	FREQ4	WD	MEAN
MEN	2.88	2.88	2.88	2.88	640	761
COME	2.79	2.97	2.88	3.23	440	963
AMERICAN	2.76	2.94	2.82	2.38	900	963
HOME	2.74	2.81	2.78	3.15	660	845
PART	2.69	2.79	2.79	2.70	280	798
GENERAL	2.69	2.82	2.71	2.27	640	785
END	2.61	2.78	2.72	2.73	580	807
IMPORTANT	2.56	2.70	2.58	1.90	1080	906
COMPANY	2.46	2.61	2.58	2.38	720	771
CAR	2.43	2.58	2.58	2.65	460	870
ECONOMIC	2.39	2.59	2.41	1.92	700	905
AGE	2.36	2.47	2.39	2.15	440	810
COST	2.36	2.62	2.61	2.43	700	1041
CENTURY	2.31	2.46	2.40	1.60	1200	1230
LOW	2.24	2.34	2.27	1.90	760	1131
ADMINISTRATION	2.20	2.37	2.20	1.56	1320	1039
BUILDING	2.20	2.56	2.37	2.67	680	755
CLUB	2.16	2.24	2.23	2.05	600	1005
READING	2.15	2.61	2.52	2.67	720	859
LIST	2.12	2.34	2.32	1.56	640	942
ARMY	2.12	2.40	2.17	2.44	840	758
AID	2.11	2.25	2.24	1.38	720	906
ASK	2.11	2.79	2.79	2.34	600	1065
CONSIDER	2.10	2.75	2.53	2.36	840	986
CHIEF	2.08	2.19	2.10	1.56	440	856
CHARACTER	2.07	2.51	2.19	1.60	740	986
BALL	2.04	2.15	2.10	1.94	580	900
HOSPITAL	2.04	2.11	2.11	2.11	800	953
ATTITUDE	2.03	2.19	2.19	1.51	920	895
JAZZ	1.99	2.00	2.00	.90	700	950
BALANCE	1.95	2.07	2.07	1.68	780	806
ADD	1.94	2.64	2.47	1.51	320	869
COFFEE	1.89	1.91	1.89	2.25	500	791
BROTHER	1.86	2.08	2.06	2.63	540	707
FORREST	1.82	1.95	1.94	.00	720	886
HUNG	1.81	1.81	1.81	1.51	680	895
FAT	1.78	1.98	1.89	1.30	440	838
KID	1.78	2.04	1.97	2.84	460	934
CONCLUSION	1.77	2.23	1.98	1.20	1200	1061
BREAKFAST	1.72	1.76	1.76	1.60	880	893
INDIAN	1.72	1.92	1.92	1.51	800	799
COUSIN	1.71	1.78	1.78	1.56	620	839
CONTRIBUTE	1.64	2.26	2.03	.60	960	1061
FUN	1.64	1.94	1.64	2.01	480	1219
DECIDE	1.60	2.32	2.31	2.52	840	1010
INCH	1.60	2.10	2.10	1.89	600	807
PAPA	1.60	1.60	1.60	.00	480	846
GATE	1.57	1.75	1.72	1.20	520	759
ROW	1.54	1.72	1.71	1.48	680	1050

(APPDNDIX D CONTINUED)

WORD	FREQ1	FREQ2	FREQ3	FREQ4	WD	MEAN
CANDIDATE	1.53	1.89	1.86	1.45	760	1336
MUD	1.51	1.64	1.62	.60	640	788
INNOCENSE	1.45	1.86	1.45	.00	940	865
CIGARETTE	1.39	1.58	1.57	2.02	960	1029
JUMP	1.38	1.86	1.85	1.83	340	840
BOSS	1.36	1.43	1.41	1.98	640	765
GIN	1.36	1.38	1.38	.00	440	802
CHAMPION	1.36	1.62	1.52	.60	860	1105
INCREDIBLE	1.36	1.51	1.48	.00	1060	1047
FAN	1.26	1.68	1.59	1.08	620	868
LECTURE	1.20	1.62	1.56	1.45	1000	1076
ACE	1.18	1.28	1.28	.00	660	852
COP	1.18	1.51	1.51	1.20	440	928
ACID	1.11	1.32	1.30	.00	560	917
ALCOHOL	1.11	1.36	1.18	1.45	880	913
CANE	1.08	1.08	1.08	1.56	660	964
INNING	1.08	1.20	1.20	.00	520	876
ADOLESCENT	1.07	1.57	1.28	.00	920	936
COSTUME	1.00	1.46	1.46	.60	780	972
HANDKERCHIEF	.95	1.00	1.00	.00	1120	1155
CLAD	.84	.90	.84	.00	620	1166
BANG	.80	1.32	1.18	1.51	760	964
LUXURIOUS	.78	1.49	.78	.60	1060	1675
BACHELOR	.70	1.00	1.00	1.08	740	897
BALD	.70	1.00	.84	.90	640	986
FRIGID	.70	.70	.70	.00	480	837
GASP	.70	1.23	1.23	.00	340	940
GLIB *	.70	.70	.70	.00	480	902
HEMMORAGE	.70	.90	.90	.00	1260	922
HUM	.70	1.15	1.15	.60	900	779
COMPASSION	.69	.95	.69	.00	1080	1125
ALTITUDE	.60	.60	.60	1.20	1200	952
COY	.60	.70	.70	.00	280	1070
ENTOURAGE	.60	.60	.60	.00	1040	1194
GLAMOUR	.60	1.18	.70	.60	640	886
CONTINGENT	.48	1.28	.90	.00	1400	1418
HUG	.48	1.11	1.08	.00	640	791
JOT	.48	.48	.48	.60	600	983
BROTHEL *	.40	.40	.40	.00	740	999
BRUISE	.40	1.30	1.30	.60	840	1054
CHOP *	.40	1.25	1.25	1.08	460	1137
ARID	.30	.60	.60	.60	560	955
ASSIMILATE	.30	1.15	1.15	.00	1020	1014
CHEW	.30	1.28	1.28	.00	560	867
DECEIT	.30	1.04	.48	.00	920	895
FAD	.30	.48	.48	.00	480	940
HIVE	.30	.30	.30	.00	560	983
PAL	.30	.48	.48	.90	460	852
PRICKLY	.30	.85	.60	.00	860	980
QUIZZICAL	.30	.85	.60	.00	860	1076

REFERENCES

Achenback, T.M. (1969). Cue learning, associative responding, and school performance in children. Developmental Psychology, 1, 717-725.

Alford, J.A. (1978, April). The interaction of length and frequency in word recognition. Paper presented at the meeting of the Southwestern Psychological Association, New Orleans, LA.

Bachman, M.E. (1972). Patterns of mental abilities:Ethnic, socioeconomic, and sex differences. American Educational Research Journal, 9, 1-12.

Becker, C.A. (1976). Allocation of attention during visual word recognition. Journal of Experimental Psychology: Human Perception and Performance, 2, 556-566.

Bias, R.G. (1979). Phonological recoding of words in isolation and prose (Doctoral dissertation, University of Texas at Austin, 1978). Dissertation Abstracts International, 39, 3550B.

Bias, R.G., & McCusker, L.X. (1980). Phonological recoding in lexical decision at recognition threshold. Journal of Reading Behavior, 12, 5-21.

Blosfelds, M.E., & Bradley, D.C. (1981, November). Visual and auditory word recognition: Effects of frequency and syllabicity. Paper presented to the Third Australian Language and Speech Conference, Melbourne University.

Bradley, D.C. (1878). Computational distinctions of vocabulary type unpublished Doctoral dissertation, Massachusetts Institute of Technology, 1978).

Bradley, D.C., Garrett, M.F., & Zurif, E.B. (1980). Syntactic deficits in Broca's aphasia. In D. Caplan (Ed.), Biological Studies in Mental Processes, MIT Press, Cambridge, MA.

Butler, B. & Hains, S. (1979). Individual differences in word recognition latency. Memory and Cognition, 7, 68-76.

Bradshaw, J.L. (1975). Three interrelated problems in reading: A review. Memory and Cognition, 3, 123-124.

Carrol, M. & Kirsner, K. (1982). Context and repetition effects in lexical decision and recognition memory. Journal of Verbal Learning and Verbal Behavior, 21, 55-69.

Chomsky, C. (1970). Reading, writing, and phonology. *Harvard Educational Review*, *40*, 287-3;.tp409.

Circelli, V.G. (1967). Sibling constellation, creativity, IQ, and academic achievement. *Child Development*, *38*, 481-490.

Clark, H.H. (1973). The language as a fixed effect fallacy: A critique of language statistics in psychological research. *Journal of Verbal Learning and Verbal Behavior*, *12*, 335-359.

Cosky, M.J. (1976). The role of letter recognition in word recognition. *Memory and Cognition*, *4*, 207-214.

Dixon, P., & Rothkopf, E.Z. (1979). Word repetition, lexical access, and the process of searching words and sentences. *Journal of Verbal Learning and Verbal Behavior*, *18*, 629-644.

Earhard, B. (1982). Determinants of the word-frequency effect in recognition memory. *Memory and Cognition*, *10*, 115-124.

Egido, C. (1981). *Auditory word frequency effects for open and closed class stimuli*. Unpublished manuscript.

Forbach, G.G., Stanners, R.F., & Hochhaus, L. (1974). Repetition and practice effects in lexical decision tasks. *Memory and Cognition*, *2*, 337-339.

Forster, K.I. (1976). Accessing the mental lexicon. In R.J. Wales and E.C.T. Walker (Eds.), *New Approaches to Language Mechanisms*. North-Holland, Amsterdam.

Forster, K.I. (1981). Frequency blocking and lexical access: One mental lexicon or two? *Journal of Verbal Learning and Verbal Behavior*, *20*, 190-203.

Forster, K.I., & Bednall, F.S. (1976). Terminating and exhaustive search in lexical access. *Memory and Cognition*, *4*, 53-61.

Forster, K.I., & Chambers, S.M. (1973). Lexical access and naming time. *Journal of Verbal Learning and Verbal Behavior*, *12*, 627-635.

Frederiksen, J.R. & Kroll, J.F. (1976). Spelling and sound: Approaches to the internal lexicon. *Journal of Experimental Psychology: Human Perception and Performance*, *2*, 361-379.

Glanzer, M. & Ehrenreich, S.L. (1979). Structure and search of the internal lexicon. *Journal of Verbal Learning and Verbal Behavior*, *18*, 381-398.

Goedel, G.D. & Englert, J.A. (1978). The imagery effect and phenomenal background frequency in verbal discrimination learning. Memory and Cognition, 6, 209-216.

Gordon, B. (1983). Lexical access and lexical decision: Mechanisms of frequency sensitivity. Journal of Verbal Learning and Verbal Behavior, 22, 22-44.

Hillenger, M.L. (1980). Priming effects with phonemically similar words: The encoding-bias hypothesis reconsidered. Memory and Cognition, 8, 115-123.

Howes, D.H. (1951). A word count of spoken English. Journal of Verbal Learning and Verbal Behavior, 5, 572-604.

Howes, D.H. & Solomon, R.L. (1951). Visual duration threshold as a function of word probability. Journal of Experimental Psychology, 41, 401-410.

Howes, D. (1957). On the relation of the intelligibility and occurance of English words. Journal of Acoustical Society of America, 29, 296-309.

Jastrezembski, J.E. (1981). Multiple meanings, number of related meanings, frequency of occurence, and the lexicon. Cognitive Psychology, 13, 278-305.

Kucera, H., & Frances, W.N. (1967). Computational Analysis of Present-day American English. Providence, R.I.: Brown University Press.

Landauer, T.K. (1975). Memory without organization: Properties of a model with random storage and undirected retrieval. Cognitive Psychology, 7, 495-531.

Levy, B.A. (1975). Vocalization and suppression effects in sentence memory. Journal of Verbal Learning and Verbal Behavior, 14, 304-316.

Maccoby, E.E., & Jacklin, C.N. (1974). The Psychology of Sex Differences. Stanford, CA.: Stanford University.

Martin, M. (1978). Speech recoding in silent reading. Memory and Cognition, 6, 108-114.

McCusker, L.S. (1977). In P.B. Gough (Chair) Some determinants of word recognition. Symposium presented at the meeting of the Southwestern Psychological Association, Fort Worth, Texas.

McCusker, L.X., Cosky, M.J., & Gough, P.B. (1977, December). Phonological interference in proofreading: Evidence for the primacy of phonological recoding in lexical access. Paper presented at the meeting of the National Reading Conference, New Orleans, LA.

McCusker, L.X., Hillenger, M.L., & Bias, R.G. (1981). Phonological recoding and reading. Psychological Bulletin, 89, 217-245.

McGinnes, E., Comer, P.B., & Lacey, O.L. (1952). Visual recognition thresholds as a function of word length and word frequency. Journal of Experimental Psychology, 44, 65-67.

Meyer, D.B., & Gutschera, K.D. (1975, November). Orthographic vs. phonemic processing of printed words. Paper presented as the meeting of the Psychonomic Society, Denver, Colo.

Meyer, D.e., & Ruddy, M.G. (1973, November). Lexical-memory retrieval based on graphemic and phonemic representations of printed words. Paper presented at the meeting of the Psychonomic Society, St. Louis, Mo.

Meyer, D.E., Schvanenveldt, R.W., & Ruddy, M.G. (1974). Functions of graphemic and phonemic codes in visual word recognition. Memory and Cognition, 2, 309-321.

Monday, L.A., Hout, D.& Lutz, S.W. (1966-1967). College Student Profiles: American College Testing Program. Iowa City: Act Publications.

Morton, J. (1970). A functional model of human memory. In D.A. Normon (Ed.), Models of Human Memory. New York: Academic Press.

Nas, G. (1983). Visual word recognition in bilinguals: Evidence for a cooperation between visual and sound based codes during access to a common lexical store. Journal of Verbal Learning and Verbal Behavior, 22, 526-534.

O'Connor, R.E. & Forster, K.I. (1981). Criterion bias and search sequence bias in word recognition. Memory and Cognition, 9, 78-91.

Postman, L., & Adis-Castro, G. (1957). Psychophysical methods in word recognition. Science, 43, 142-154.

Rosenberg, B.G. & Sutton-Smith, B. (1964). the relation of ordinal position and sibling sex status to cognitive abilities. Psychonomic Science, 1, 80-82.

Rosenberg, B.G., & Sutton-Smith, B. (1969). Sibling age spacing effects upon cognition. Developmental Psychology, 1, 661-668.

Rozenweig, M.R., &Postman, L. (1958). Frequency of usage and the perception of words. Science, 27, 263-266.

Rubenstein, H., Garfield, L., & Millikan, J.A. (1970). Homographic entries in the internal lexicon. Journal of Verbal Learning and Verbal Behavior, 9, 487-494.

Rubenstein, H., Lewis, S.S., & Rubenstein, M.A. (1971). Evidence for phonemic recoding in visual word recognition. Journal of Verbal Learning and Verbal Behavior, 10, 645-657.

Scarborough, D.L., Cortise, C., & Scarborough, H.S. (1977). Frequency and repetition effects in lexical memory. Journal of Experimental Psychology, 3, 1-17.

Scharff, J.L. (1981). The effects of word length, word frequency, and word recency with auditory stimuli. Unpublished manuscript.

Schulman, A.J. (1967). Word length and rarity in recognition memory. Psychonomic Science, 9, 211-212.

Shepard, W.O. (1970). Word association and definition in middle childhood. Developmental Psychology, 3, 412.

Solomon, R.L., & Postman, L. (1952). Frequency of usage as a determinant of recognition thresholds for word. Journal of Experimental Psychology, 43, 195-201.

Spoehr, K.T. (1978). Phonological encoding in visual word recognition. Journal of Verbal Learning and Verbal Behavior, 17, 127-141.

Spoehr, K.T., & Smith, E.E. (1973). The role of syllables in perceptual processing. Cognitive Psychology, 5, 71-89.

Spoehr, K.T., & Smith, E.E. (1975). The role of orthographic and phonotactic rules in perceiving letter patterns. Journal of Experimental Psychology: Human Perception and Performance, 104, 21-34.

Stanners, R.F., & Forbach, G.B. (1973). Analysis of letter strings in word recognition. Journal of Experimental Psychology, 98, 31-35.

Stanners, R.F., Jastrzembski, J.E., & Westbrook, A. (1975). Frequency and visual quality in a non-word classification task. Journal of Verbal Learning and Verbal Behavior, 14, 259-264.

Stanovich, K.E., & Bauer, D.W. (1978). Experiments on the spelling to sound regularity effect in word recognition. Memory and Cognition, 6, 410-415.

Sternberg, S. (1969). Memory-scanning: Mental processes revealed by reaction-time experiments. American Scientists, 57, 421-457.

Svenson, A. (1971). Relative Achievement. School performance in relation to intelligence, sex, and home environment. Stockholm: almquist & Wiksell.

Swift, D.J. (1977). The effects of context, word frequency, and internal redundancy in reading and word perception (unpublished Doctoral dissertation, University of New Hampshire, 1977). Dissertation Abstracts International,

Swift, D.J. (1984). The nature of the function relating word frequency to reaction time. Unpublished manuscript, University of Michigan, Dearborn, MI.

Thorndike, E.L., & Lorge, I. (1944). The Teachers Word Book of 30,000 Words. New York: Columbia University, Teachers College Bureau of Publications.

Very, P.S. (1967). Differential factor structures in mathematical abilities. Genetic Psychology Monographs, 75, 164-207.

Walberg, H.J. (1969). Physics, femininity, and creativity. Developmental Psychology, 1, 47-54.

Whaley, C.P. (1978). Word-nonword classification time. Journal of Verbal Learning and Verbal Behavior, 17, 143-154.

Warm, J.S., & McCray, R.E. (1969). Influence of word frequency and length of apparent duration of tachistoscopic presentation. Journal of Experimental Psychology, 79, 56-58.

Winer, B.J. (1977). Statistical Principles in Experimental Design. New York: McGraw Hill Book Co.